9.4 Planning Process

9.4.5 State IHMT Meeting: April 2014

State Interagency Hazard Mitigation Team
REV. DRAFT Meeting Agenda

Meeting Date & Time: Thursday, April 17, 2014, 9:00 to 11:30 a.m.

Meeting Location: Maj. Gen. Donald N. Anderson Readiness Center
3225 State Street[1] Salem 97301
Room #115, State ECC[2]

1) Introductions [5 minutes]
Dennis Sigrist, OEM

2) Action on minutes of January 16 meeting (distributed by email on April 11) [5 minutes]
Dennis

3) Hazard mitigation for new Presidential major disaster declaration (FEMA-4169-DR-OR) [15 minutes]
Dennis

4) Oregon NHMP Risk Assessment Update [30 minutes]
Lisa Corbly, DLCD

5) Oregon NHMP Goals and Mitigation Actions [60 minutes]
Marian Lahav, DLCD

6) Other business [15 minutes]
Dennis, facilitating

7) Discuss/develop possible agenda items for July meeting [10 minutes]
Dennis, facilitating

8) Public comment [Each public speaker is limited to three minutes, unless the time is extended by the Chair.]
Dennis, facilitating

9) Adjourn

The next three meetings of the State IHMT are scheduled for July 17, October 16, and January 15.

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[1] Access to the Donald N. Anderson Readiness Center is via a controlled gate on Geer Drive NE, which is west of the building. A guard will ask for identification when you reach the entrance to the parking lot. Once inside the fence, standard entry to OEM's facility is through the double doors (use the portico walkway) on the east end of the building (Hawthorne Avenue side). Please do not park inside the chain-link fenced area on the east end. You may park anywhere outside of the chain-link fenced area.

[2] The meeting location is accessible to persons with disabilities. A request for an interpreter for the hearing impaired or for other accommodations for persons with disabilities should be made at least 48 hours before the meeting to Cherie Cline at 503-378-2911, ext. 22221 or TDD/TTY 503-373-7857. Questions about the agenda should be addressed to Joseph Murray via email joseph.murray@state.or.us or ext. 22240 or TDD/TTY as noted above.

DRAFT

Minutes of the
April 17, 2014 meeting of the
State Interagency Hazard Mitigation Team

Meeting location: This meeting was held in the State Emergency Coordination Center (ECC) within the Donald N. Anderson Readiness Center in Salem.

The following people participated in the meeting:

Oregon Partnership for Disaster Resilience (OPDR)	Michael Howard
DAS – Chief Financial Office	Daniel Christensen
Oregon Department of Agriculture (ODA)	Ryan Scholz
DCBS, Insurance Division	Kevin Jeffries
	Tracie Weeder
Department of Environmental Quality (DEQ)	Don Pettit (on telephone)
Oregon Department of Forestry (ODF)	Cindy Kolomechuk
Dept. of Geology and Mineral Industries (DOGAMI)	Jed Roberts
OHA – Oregon Public Health Division	Jere High
Dept. of Land Conservation and Development (DLCD)	Matt Crall
	Marian Lahav
	Steve Lucker
	Lisa Peffer
	Chris Shirley
Department of State Lands	Bill Ryan
OMD, Office of Emergency Management (OEM)	Sean McCormick
	Joseph Murray
	Dennis Sigrist
Oregon Department of Transportation (ODOT)	Greg Ek-Collins
Public Utility Commission (PUC)	Rick Carter
Water Resources Department (WRD)	Alyssa Mucken
Benton County Emergency Management	Eric Rau
United States Geological Survey (USGS)	Tom Carlson (on telephone)

The following were distributed during the meeting:

- *Meeting agenda*
- *Draft minutes of the January 16, 2014 meeting* (agenda item #2)
- *FEMA-4169-DR Oregon Disaster Declaration as of 04/04/2014* slideshow (agenda item #3)
- *Oregon NHMP Risk Assessment Update* slideshow (agenda item #4)
- Memo to State IHMT dated April 11, 2014 from Marian Lahav (agenda item #5)
- *2015 Oregon NHMP Update* slideshow (agenda item #5)
- *2012 Oregon Natural Hazards Mitigation Plan Goals and Hazards* (agenda item #5)
- *Priority FOR IHMT Apr 17 AllHaz table (agenda item #5)*
- FEMA ANNOUNCES FUNDING OPPORTUNITY… (agenda item #6)

[Email joseph.murray@state.or.us for a copy of one or more meeting handouts.]

1) Introductions

   Dennis opened the meeting at 9:03 a.m. with telephone and microphone instructions, followed by introductions.

2) Action on minutes of January 16 meeting

   A draft had been distributed by email on April 11. The minutes were deemed acceptable as drafted.

3) Hazard mitigation for new Presidential major disaster declaration (FEMA-4169-DR-OR)

Dennis used a brief slideshow to organize this agenda item. He noted that Benton, Lane, Lincoln, and Linn are the declared counties. He said that Lane County not only has the most land area of these four, but also the largest losses, about 85% of the total. He noted that Oregon may appeal FEMA's denial to include Hood River County in this declaration. Dennis said that the Hazard Mitigation Grant Program (HMGP) for this declaration is available statewide with an emphasis in the declared counties. Dennis said an Applicants' Briefing had occurred the day prior.

Michael asked if potential Lincoln County applicants will be affected by the expiration of the FEMA approval of their mitigation plan in July. Dennis agreed this may preclude applications from Lincoln County. There may be a way to place a "hold" on a project, however, until the NHMP is re-approved.

Dennis said that one emphasis will be on "undergrounding" of utilities. Dennis showed examples of past projects like this that have proven successful. Rick noted that he does not necessarily support undergrounding due to that action increasing susceptibility to earthquake and landslide risks.

Dennis said another emphasis will be on tying mitigation opportunities to projects being accomplished under FEMA's Public Assistance (PA) Program for this declaration.

There is a 7% set-aside for planning, and there are likely to be applications to develop or update/expand local NHMPs (Lane County and Oregon State University). There is also a 5% set-aside for non-traditional projects.

4) Oregon NHMP Risk Assessment update

Lisa noted that this is the first time that DLCD has had the lead role for an Oregon NHMP update, including the risk assessment. She presented a slideshow. She described the eight physiographic natural hazard regions we have long used in the Oregon NHMP. She said that this was done in order to meet a FEMA criterion related to evaluation at a "local" level.

She noted that climate change is covered in the introduction, and then integrated where it applies to the eleven hazards we analyze. She noted that Nancy Murphy at ODOT helped update the lifeline portion of "vulnerabilities." Lisa said that "the state facility vulnerability now includes text, tables, and maps." She noted that OPDR is currently updating the regional profiles. She referred to local hazard analyses that are based on local knowledge. She said that the state vulnerability assessment is done with "no standardized methodology using subjective expert knowledge." She then showed a slide "Comparison: State and Local RA Vulnerability."

She noted a Risk Assessment Sub-Committee (RASC) to the State IHMT met between March and August 2013, working with the University of Oregon InfoGraphics Lab. She noted a grant proposal made to NOAA to help fund risk assessment work in Oregon; we ought to know if we are awarded a grant for this work by the end of May.

She thanked the state hazard leads. Greg thanked Lisa for her patience with the state hazard leads.

Lisa distributed a paper survey; it is due back to Marian not later than April 24. She will also distribute it by email. It is already on the project website. Marian asked people to sign-up for the list_serv if they have not already done so.

5) Oregon NHMP Goals and Mitigation Actions

Marian showed a slideshow, and had three other handouts. There was a discussion around the first of three slides on decisions we have tentatively made, the first regarding "…three opportunities for state/local dialogue on local vulnerability assessments in the next year." Sean thinks this is achievable. He noted that both OEM and OEMA[1] hold annual conferences, which could provide two of the three. We then decided to drop the "in the next year" part of this.

Then there was a discussion centered around "collaborate with local governments to improve the accuracy of potential loss totals by more accurately identifying critical/essential facilities and determining their property values." "How do we establish values and what will the product/database be at the end?"[2]

We then talked about the decision "improve state agency procedures for tracking data on state-owned and state–leased buildings and critical/essential facilities." Daniel spoke-up, noting the work DAS is doing to improve data and data standards. He said that the vision "is to make our data as robust as possible." DAS wants input from DLCD and others on how to go about this. "We can swing the hammer if we need to." He noted that DAS is already working with DOGAMI on this. Don then spoke-up: he wanted to know more about the data being discussed. Daniel said, "statewide owned and leased building data." Daniel noted that he is the State Facility Planner at DAS. Don talked briefly about the state Hazards FIT[3] and Preparedness FIT, noting that DOGAMI has the lead on the former and DEQ on the latter. Daniel noted that he has been working with Yumei Wang at DOGAMI. Joseph noted that Jed, Steve, and he are all members of the Hazards FIT. Matt invited Daniel to re-write this in the context of DAS objectives.

The next decision discussed was "develop an improved methodology for gathering data and identifying the communities most vulnerable to drought." Alyssa asked that the word "impacts" be added to this. She noted that one of WRD's Legislative Concepts has the goal of being able to "tell the drought story in a better way." She noted that with current resources, WRD cannot accomplish this within the next three years.

Finally, we talked about "establish a program for studying winter storms and their impacts statewide. Install snowfall sensors throughout the state to develop annual snowfall data." Greg modified this with regard to snowfall sensors, making it a bit broader. Dennis mentioned the NRCS snow data. Greg said that they have only about a dozen sites statewide, so in actuality we have almost no data. He went on to say that what NRCS data we *do* have is mostly in the Cascade Range. Jed noted that the OCCRI[4] may be able to help or have an interest, and that this might be better if divided into two actions.

There was a discussion about whether we ought to do more analysis of the dust storm hazard. The tentative answer is that we have higher priority areas in which to focus.

Marian then asked if the State IHMT wishes to add any new goals to the Oregon NHMP (slide 11). In this context, it was noted that for "increase communication, collaboration, and coordination among agencies at all levels of government to mitigate natural hazards," the Flood Mitigation Subcommittee, also known as Oregon Silver Jackets (SJ), could be considered a success story. Marian noted that SJ is starting to drive actions in local NHMPs.

Marian then noted that the risk assessment has a relationship with the plan goals, which then drive our actions. She asked "should we prioritize the hazards?" Dennis asked if this would minimize our flexibility? He went on to say that the Oregon Legislature has prioritized earthquake as a hazard for us. There was a long and interesting discussion. Dennis and

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[1] OEMA is Oregon Emergency Management Association.
[2] If this question was answered, Joseph's notes do not reflect the answer.
[3] FIT is Framework Implementation Team.
[4] OCCRI is Oregon Climate Change Research Institute.

Greg both noted that FEMA's main interest seems to be in recurring hazards. Lisa noted the RASC literature review, which includes information on which states prioritize hazards and how they go about it. She noted that she will make this information available. Eventually it was decided to pick-up this discussion again at the October meeting. Marian then asked that the State IHMT agencies with "lead" responsibility for actions do the following not later than April 30 for those actions:

- Review the Priority Worksheet for errors and completeness, redundancy, and for "SMARTness."
- Provide corrections, revisions, missing or necessary additional information, and recommendations for moving actions to Ongoing or Removed.

She then summarized "process and schedule" slides. Finally, Marian emphasized that comments on the Oregon NHMP update to-date, including the risk assessment are due not later than April 30.

6) Other business

Dennis thanked Tracie for her recent help with a non-NFIP[5] policy ICC claim. Tracie then talked a bit about a change SAFECO proposes to make that would affect "tens of thousands of policies in Oregon," It has filed for a rate increase of up to 50% on earthquake policies. This proposal will be reviewed by Insurance Division actuaries; it won't simply automatically go into effect. Dennis noted and Tracie confirmed that some companies have started writing stand-alone earthquake policies in Oregon, and some have stopped writing new policies.

Tracie said that her agency is currently studying the saturation rate for various types of insurance policies in Oregon; she plans to share the results at a future meeting.

Chris noted that there is a new product called a "catastrophic peril policy" that includes flood losses with premiums less than NFIP policies, especially if your building is not in compliance with floodplain standards.

Dennis noted that the HMA-14[6] application period will open on April 21 and close on July 7 (deadline to OEM) with an emphasis on certain types of applications. Information will be posted to the OEM website. The FMA emphasis is on Severe Repetitive Loss (SRL) properties. We have about twelve of those in Oregon. Chris and Dennis will conduct outreach for FMA. Dennis and Joseph will conduct outreach to local governments for PDM planning applications. Dennis noted that HMA-13 has not been awarded by FEMA to date.

Cindy asked for a definition of SRL, which Chris provided. Sean asked if seismic projects still have a priority under PDM. Dennis said he does not know for "14," but will find-out and post an answer to the OEM website.

7) Discuss/develop possible agenda items for July meeting

Due to being over the scheduled time for the meeting, this agenda item was not covered.

8) Public comment

No members of the general public were present, so there was no public comment.

9) Adjourn

The meeting was adjourned at 11:39 a.m.

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[5] NFIP is National Flood Insurance Program and ICC is Increased Cost of Compliance.
[6] HMA is Hazard Mitigation Assistance, which includes Pre-Disaster Mitigation (PDM) and Flood Mitigation Assistance (FMA).

Oregon NHMP
Risk Assessment

For the IHMT
April 17th, 2014

Lisa Corbly, DLCD

Risk Assessment

- What’s In It
- What Changed
- Messages
- Recommendations
- Next Steps

RA: What's In It?

TOC

- Introduction
- Executive Summary
- State RA
- Regional RAs

RA TOC

- State Risk Assessment
  - Oregon Hazards
  - Oregon Vulnerabilities

RA TOC

- State Risk Assessment
  - Oregon Hazards
    - Overview
    - Introduction to Climate Change
    - Hazards *(per hazard)*
      - Analysis & Characterization
      - Historic Events
      - Probability

RA Table of Contents

- State Risk Assessment
  - Oregon Hazards
  - Oregon Vulnerabilities
    - Overview
    - Local Vulnerability Assessments
    - State Vulnerability Assessments
    - Local & State Comparison
    - State Facilities & Critical/Essential Facilities Loss Estimates
    - Seismic Lifeline Vulnerabilities
    - Future Enhancements to State RA

RA Table of Contents

- Regional Risk Assessments *(per region)*
  - Regional Summary
  - Regional Profile
  - Regional Hazards & Vulnerability (*per hazard)*
    - Characteristics
    - Significant Events
    - Probability
      - Local
      - State
    - Vulnerability
      - Local
      - State
    - State Facilities & Critical/Essential Facilities Loss Estimates (maps)
    - Lifeline Vulnerabilities

Local vs. State Vulnerability Assessment Methods

Requirement: 44 CFR §201.4(c)(2)(ii): Th[e] risk assessment shall include… (ii) (a)n overview and analysis of the State's vulnerability to the hazards described . . . based on estimates provided in local risk assessments as well as the State risk assessment. The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events…

Local OEM Hazard Analysis

- Circa 1980s
- Used nationally
- History, Probability, Vulnerability
- High, Moderate, Low
- Weighted and scored
- Local knowledge (subjective)
- Identifies priority hazards
- County/city level

Local Vulnerability Assessment Rankings

Table 2.3: Local Perceived Hazard Vulnerability

County	Coastal Erosion	Drought	Dust Storm	Earthquake	Wildfire	Flood	Landslide/ Debris Flow	Tsunami	Volcano	Wind Storm	Winter Storm
Baker		High		Low	Medium	High				[Moderate]	High
Benton		Low		High	Moderate	Moderate	Low		Low	Moderate	Moderate
Clackamas		Low		High	Moderate	Moderate	Low		High	Low	Moderate
Clatsop	High	Moderate		High	High	High	High	High	Moderate	Moderate	High
Columbia		Low		High	Moderate	High			Moderate	High	High
Coos	[Moderate]	Moderate		High	Moderate	High	Low	High		High	
Crook				Low	Moderate	High	Low		High	Moderate	High

H= High vulnerability
M= Moderate vulnerability
L= Low vulnerability

State Vulnerability Assessment

- Hazard leads
- No standardized method
- Research, literature, expert knowledge (subjective)
- Data quality and quantity varies
- Most Vulnerable, (Vulnerable)
- Relativist (statewide)

State Identified
Most **V**ulnerable Communities

Local and State Vulnerability Rankings by County											
County	Coastal Erosion	Tsunami	Drought	Dust Storm	Earthquake	Volcanic	Landslide	Wildfire	Flood	Wind Storm	Winter Storm
	State	*State*	*State*	*State*	*State*	*State*	*State*	*State*	*State*	*State*	*State*
1	MV	MV			MV		MV	V	V	MV	
2	V	MV			MV		MV	MV	V	MV	
3	MV	MV			MV		MV	V	V	MV	
4	MV	MV			V		MV	V	MV	MV	
5				V	V	MV	MV	MV		V	

MV= Most vulnerable community
V= Vulnerable community

Comparison:
State and Local RA Vulnerability

Local and State Vulnerability Rankings by County																						
County	Coastal Erosion		Tsunami		Drought		Dust Storm		Earthquake		Volcanic		Landslide		Wildfire		Flood		Wind Storm		Winter Storm	
	Local	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*
1	H	MV	H	MV	M				H	MV	M		H	MV	H	V	H	V	H	MV	H	
2	M	V	H	MV	M				H	MV	M		M	MV	M	MV	H	V	H	MV	H	
3		MV	M	MV	L				M	MV	L			MV	M	V	L	V	H	MV		
4		MV	H	MV	L		L		H	V	M		H	MV	H	V	H	MV	H	MV	H	
5					H			V	M	V	L	MV	M	MV	M	MV	L		H	V	H	

H= High vulnerability
M= Moderate vulnerability
L= Low vulnerability

MV= Most vulnerable community
V= Vulnerable community

Comparison:
State and Local RA Vulnerability

Local and State Vulnerability Rankings by County																						
County	Coastal Erosion		Tsunami		Drought		Dust Storm		Earthquake		Volcanic		Landslide		Wildfire		Flood		Wind Storm		Winter Storm	
	Local	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*
1	H	MV	H	MV	M				H	MV	M		H	MV	H	V	H	V	H	MV	H	
2	M	V	H	MV	M				H	MV	M		M	MV	M	MV	H	V	H	MV	H	
3		MV	M	MV	L				M	MV	L			MV	M	V	L	V	H	MV		
4		MV	H	MV	L		L		H	V	M		H	MV	H	V	H	MV	H	MV	H	
5					H			V	M	V	L	MV	M	MV	M	MV	L		H	V	H	

H= High vulnerability
M= Moderate vulnerability
L= Low vulnerability

MV= Most vulnerable community
V= Vulnerable community

Vulnerability to most hazards ranked similarly by both local and state risk assessments

Comparison:
State and Local RA Vulnerability

Local and State Vulnerability Rankings by County																						
County	Coastal Erosion		Tsunami		Drought		Dust Storm		Earthquake		Volcanic		Landslide		Wildfire		Flood		Wind Storm		Winter Storm	
	Local	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*
1	H	MV	H	MV	M				H	MV	M		H	MV	H	V	H	V	H	MV	H	
2	M	V	H	MV	M				H	MV	M		M	MV	M	MV	H	V	H	MV	H	
3		MV	M	MV	L				M	MV	L			MV	M	V	L	V	H	MV		
4		MV	H	MV	L		L		H	V	M		H	MV	H	V	H	MV	H	MV	H	
5					H			V	M	V	L	MV	M	MV	M	MV	L		H	V	H	

H= High vulnerability
M= Moderate vulnerability
L= Low vulnerability

MV= Most vulnerable community
V= Vulnerable community

Hazard not ranked, or ranked as “L”, by local jurisdiction, ; and ranked as “MV” by state.

State RA Messages

A. Wide ranging hazard data
B. No standardized statewide RA
C. Similarities/differences in local & state RA
D. Related hazards
E. Facility data gaps

State RA Recommendations

A. Wide ranging hazard data → Enhance; Prioritize

B. No standardized statewide RA → Develop

C. Similarities/differences in local & state RA → Analyze

D. Related hazards → Collaborate

E. Facility data gaps → Improve

Next Steps

- Link state RA to goals and actions
- RA feedback
- State RA review & feedback
  - FEMA 1st review, 45 days
  - Public comment thru 4/30;
- Regional RA review & feedback: July 2014

2015 Oregon Natural Hazard Mitigation Plan

Risk Assessment

* DRAFT *

v.01, 04/10/2014

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Chapter 2
RISK ASSESSMENT

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            ii. Historical Events
            iii. Probability
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        c. State Vulnerability Assessments *(per hazard)*
        d. Local and State Vulnerability Assessments Comparison
        e. State-Owned Facilities and Critical and Essential Facilities Loss Estimates
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            iv. Lifeline Vulnerabilities *(earthquake only)*

In This Chapter

The Oregon NHMP Risk Assessment is divided into four sections: 1) introduction, 2) executive summary, 3) state risk assessment and 4) regional risk assessment. Following is a description of each section.

1. **Introduction:** *States the purpose of the risk assessment and understanding risk.*
2. **Executive Summary:** *Summarizes the analysis and findings in the State and Regional Profiles.*
3. **State Risk Assessment:** *Includes the following components:*
   - Oregon Hazards: *Profiles each of Oregon's hazards by identifying each hazard, its generalized location and presidentially declared disasters; introduces how the state is impacted by climate change; characterizing each hazard that impacts Oregon; listing historic events; identifying the probability of future events; and introducing how climate change is predicted to impact each hazard statewide.*
   - Oregon Vulnerabilities: *Includes an overview and analysis of the State's vulnerability to each hazard by identifying which communities are most vulnerable to each hazard based on local and state vulnerability assessments; providing loss estimates for State owned or leased facilities and critical or essential facilities located in hazard areas; and identifying seismic lifeline vulnerabilities.*
   - Future Enhancements: *Describes ways in which Oregon is planning to improve future state risk assessments.*
4. **Regional Risk Assessment:** *Includes the following components:*
   - Regional Summary: *Summarizes the OEM Natural Hazard Region's statistical profile, hazard and vulnerability analysis; and projected impacts of climate change on hazards in the region.*
   - Regional Profile: *Provides an overview of the region's unique characteristics, including a natural environment profile, social /demographic profile, economic profile, infrastructure profile, and built environment profile.*
   - Regional Hazards and Vulnerability: *Further describes the hazards in each region by charactering how each hazard presents itself in the region; listing historic hazard events in the region; and identifying probability of future events based on local and state analysis. Also includes an overview and analysis of the region's vulnerability to each hazard; identifies which communities in the region are most vulnerable to each hazard based on local and state analysis; provides loss estimates for State owned or leased facilities and critical or essential facilities located in hazard areas; and identifies the region's seismic lifeline vulnerabilities.*

Introduction

Requirement 44 CFR §201.4(c)(2), [The plan must include] risk assessments that provide the factual basis for activities proposed in the strategy portion of the mitigation plan. Statewide risk assessments must characterize and analyze natural hazards and risks to provide a statewide overview. This overview will allow the State to compare potential losses throughout the State and to determine their priorities for implementing mitigation measures under the strategy, and to prioritize jurisdictions for receiving technical and financial support in developing more detailed local risk and vulnerability assessments.

Purpose

The purpose of the Oregon NHMP Risk Assessment is to identify and characterize Oregon's natural hazards, determine which jurisdictions are most vulnerable to each hazard and estimate potential losses to vulnerable structures and infrastructure and to state facilities from those hazards.

It is impossible to predict exactly when natural hazards will occur, or the extent to which they will affect communities within the state. However, with careful planning and collaboration, it is possible to minimize the losses that can result from natural hazards. The identification of actions that reduce the state's sensitivity and increase its resilience assist in reducing overall risk – or the area of overlap in Figure 2-1 below. The Oregon NHMP Risk Assessment informs the State's mitigation strategy, as found in Chapter XX (pg.XX).

Figure 2-1: Understanding Risk

Source: USGS- Oregon Partnership for Disaster Resilience Research Collaboration, 2006

Assessing the state's level of risk involves three components: characterizing natural hazards, assessing vulnerabilities and analyzing risk. Characterizing natural hazards involves determining hazards' causes and characteristics, documenting historic impacts, and identifying future probabilities of hazards occurring throughout the State. The section in this risk assessment titled Oregon Hazards characterizes each of the state's natural hazards.

A vulnerability assessment combines information from the hazard characterization with an inventory of the existing (or planned) property and population exposed to a hazard, and attempts to predict how different types of property and population groups will be affected by each hazard. Vulnerability is determined by a community's exposure, sensitivity, and resilience to natural hazards, as well as its ability to mitigate, prepare for, respond to, and recover from a disaster. The section Oregon Vulnerabilities identifies and assesses the state's vulnerabilities to each hazard identified in the Oregon Hazards section of this risk assessment.

Finally, a risk analysis involves estimating the damages, injuries, and costs likely to be incurred in a geographic area over a period of time. Risk has two measurable components: (1) the magnitude of the harm that may result, defined through vulnerability assessments, and (2) the likelihood or probability of the harm occurring, defined in the hazard characterization. Together, the Oregon Hazards and Oregon Vulnerabilities sections form the state's risk analysis.

Executive Summary

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State Risk Assessment

Oregon Hazards

Overview

Requirement: 44 CFR §201.4(c)(2)(i): Th[e] risk assessment shall include… (i) (a)n overview of the type and location of all natural hazards that can affect the State…

The state of Oregon is subject to 11 primary hazard types. Table 2-2 lists each hazard and describes in general terms where the hazard is located. Each hazard is described in greater detail later in State Risk Assessment, including an introduction, description, historical events and probability on pages 23-155. The state's vulnerability to each hazard is discussed in the Oregon Vulnerabilities section of the state risk assessment, beginning on page 156.

Table 2.2: Oregon Hazard Overview

Hazard	Generalized Locations
Coastal Hazards	West Oregon Coast
Drought	Generally east of the Cascades, with localized risks statewide
Dust Storm	Generally east of the Cascades
Earthquake	
Cascadia Subduction	Primarily Western Oregon
Other Active EQ Faults	Localized Risks Statewide
Flood	Localized risks statewide
Landslide/ Debris Flow	Localized risks statewide
Tsunami	West Oregon Coast*
Volcano	Central Oregon, Cascade Range and Southeast Oregon, High Lava Plains
Wildfire	Primarily Southwest, Central and Northeast Oregon, with localized risks statewide
Windstorm	Localized Risks Statewide
Winter Storm	Localized Risks Statewide

** Potential tsunami inundation for five levels of local Cascadia scenarios and two maximum-considered distant tsunami scenarios are available as published maps and geographic information (GIS) files through the Oregon Department of Geology and Mineral Industries (DOGAMI). GIS files were released in 2013 as Open-File Report O-13-19.*

Source: Oregon NHMP lead state agency(ies) for each hazard

Since 1955 (the year the U.S. began formally tracking natural disasters), Oregon has received 28 major disaster declarations, two emergency declarations and 49 fire management assistance declarations. Table 2.3 below lists each of the major disaster declarations, the hazard that the disaster is attributed to and counties impacted. Since 1955, Clatsop, Douglas, Lincoln, Tillamook and Yamhill Counties have each been impacted by ten or more federally declared non-fire related disasters. Of the 28 major disasters to impact Oregon, the vast majority have resulted from storm events; notably, flooding impacts from those events are reported in over two-thirds of the major disaster declarations.

The reported federal disaster declarations (including fire management assistance declarations) document that storm events, floods and wildfires have been the primary chronic hazards with major

disaster impacts in Oregon over the last half century. The data also show a trend geographically of a greater number of major federal disaster declarations in the northwest corner of the state. Anecdotally, this pattern plays out for non-federally declared hazard events in the state as well. The following subsections summarize type, location, history and probability information for each of the hazard types listed above.

Table 2.3: Presidential Major Disaster Declarations Since 1955

Disaster	Incident Period	Disaster Type	Baker	Benton	Clackamas	**Clatsop**	Columbia	Coos	Crook	Curry	Deschutes	**Douglas**	Gilliam	Grant	Harney	Hood River	Jackson	Jefferson	Josephine	Klamath	Lake	Lane	**Lincoln**	Linn	Malheur	Marion	Morrow	Multnomah	Polk	Sherman	Siletz IR	**Tillamook**	Umatilla	Union	Wallowa	Warm Springs IR	Wasco	Washington	Wheeler	**Yamhill**
DR-4055	1/17 - 1/21/2013	Severe winterstorm / flooding /landslides / mudslides		X			X	X		X		X				X						X	X	X		X			X			X								
DR-1964	3/11/2011	Tsunami						X		X													X																	
DR-1956	1/13-1/21/2011	Winter storms / flooding / mudslides / landslides / debris flows			X	X			X			X											X									X								
DR-1824	12/13-1/26/2008	Winter storms / flooding			X	X	X																			X		X	X			X						X		X
DR-1733	12/1-12/17/2007	Storms / flooding / landslides / mudslides				X	X																						X			X						X		X
DR-1683	12/14-12/15/2006	Winter storms / flooding		X		X	X																X						X		X	X					X		X	X
DR-1672	11/5-11/8/2006	Storms / flooding / landslides / mudslides				X										X							X									X								
DR-1632	12/18/2005-1/21/2006	Storms / flooding / landslides / mudslides		X	X	X	X	X	X	X		X	X				X	X	X				X	X					X	X		X				X			X	X
DR-1510	12/26/2003-1/14/2004	Winter storms	X	X	X	X	X		X		X	X	X	X	X	X		X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X
DR-1405	2/7-2/8/2002	Wind storm						X		X		X										X		X																
DR-1221	5/28-6/3/1998	Flooding							X																															
DR-1160	12/25/1996-1/6/1997	Winter storm / flooding						X				X					X		X	X	X	X													X					
DR-1107	12/10-12/12/1995	Storms / high winds		X		X	X					X										X	X	X								X						X		X
DR-1099	2/4-2/21/1996	Storms / flooding		X	X	X	X	X			X	X	X			X		X	X			X	X	X		X	X	X	X	X		X	X	X	X		X	X		X
DR-1061	7/8-7/9/1995	Flash flooding																																		X				
DR-1036	5/1-10/31/1994	El Nino effects																																						
DR-1004	9/20/1993	Earthquakes																		X																				
DR-985	3/25/1993	Earthquake			X																					X												X		X
DR-853	1/6-1/9/1990	Storms / flooding				X																										X								
DR-413	1/25/1974	Storms / snow melt / flooding		X	X		X	X		X		X	X			X	X		X			X	X			X			X			X			X		X	X		X
DR-319	1/21/1972	Storms / flooding			X	X		X				X										X	X	X				X				X						X		
DR-301	2/13/1971	Storms / flooding				X																										X								
DR-184	12/24/1964	Heavy rains / flooding	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Total number of disasters by county / IR* post 1964			2	7	9	**13**	9	8	5	5	3	**10**	5	2	2	5	4	4	5	3	3	8	**11**	7	2	6	3	5	8	4	1	**14**	3	3	5	1	6	8	4	**10**
DR-144	2/25/1963	Flooding	No individual county impact data available																																					
DR-136	10/16/1962	Storms																																						
DR-69	3/1/1957	Flooding																																						
DR-60	7/20/1956	Storm/flooding																																						
DR-49	12/29/1955	Flooding																																						

* IR = Indian Reservation

Source: Oregon Emergency Management, 2013

Introduction to Climate Change

This section presents an overview of climate change in Oregon. Climate is an important element in certain natural hazards, even though in itself, climate is not a distinct natural hazard.

In broad terms, climate in the Pacific Northwest is characterized by variability, and that variability is largely dominated by the interaction between the atmosphere and ocean in the tropical Pacific Ocean that is responsible for El Niño and La Niña. Human activities are changing the climate, particularly temperature, beyond natural variability. Climate change is already affecting Oregon communities and resources, and needs to be recognized in various planning efforts as an important stressor that significantly influences the incidence—and in some cases the location—of natural hazards and hazard events. Climate change is anticipated to affect the frequency and/or magnitude of some kinds of natural hazards in Oregon. A brief review of some of the observed changes in Oregon or the Pacific Northwest will give some idea of the influence of climate on natural hazards. First, temperatures increased across the Pacific Northwest by 1.3˚F in the period from 1895-2011 (the observed record). In that same timeframe, Cascade Mountain snowpacks have declined, and higher temperatures are causing earlier spring snowmelt and spring peak streamflows. On the coast, increasing deep-water wave heights in recent decades are likely to have increased the frequency of coastal flooding and erosion. In Oregon's forested areas, large areas have been impacted by disturbances that include wildfire in recent years, and climate change is probably one major factor. Closer to home for some Oregonians, a three-fold increase in heat-related illness has been documented in Oregon with each 10 ˚F rise in daily maximum temperature. (Dalton et al 2013, OCCRI 2010).

Oregon Responses to Climate Change

The human influence on the climate is clear (IPCC 2013). Global greenhouse gas emissions will determine the amount of warming both globally and here in Oregon. On that basis, Oregon and other states and local communities have undertaken measures to reduce greenhouse gas emissions as a way to slow the warming trend. Similarly, states and local communities are beginning to implement measures to adapt to future climate conditions that cannot be avoided. The global climate has considerable inertia, so the changes that can be anticipated today are largely a result of conditions that occurred up to several decades, almost a century ago. Inertia in the global climate system cannot be immediately influenced, so states and communities are beginning to do 'climate adaptation planning' on local and regional scales. In many cases, planning for climate change—or adaptation planning—quickly comes down to improved planning for natural hazards, since many of the anticipated effects of climate change will be experienced in the form of natural hazard events. That said, planning to adapt to climate change and planning to mitigate natural hazards are not entirely the same thing, although there is considerable overlap. Planning for climate change also includes planning for public health and natural resource protection.

In 2010, the State of Oregon produced the Oregon Climate Adaptation Framework. This framework identifies 11 climate-related risks for which the state must plan for. Five of those eleven climate risks—drought, coastal erosion, fire, flood, and landslides— are directly identified in the Oregon NHMP. In addition, three other hazards in the Oregon NHMP —wind storms, winter storms, and dust storms—have an underlying climate component.

Oregon and the Pacific Northwest have been rich in climate impacts research over the last eighteen years. In 2007, the Oregon Legislature created the Oregon Climate Change Research Institute (OCCRI) under HB3543 (OCCRI). Much of the material in this section is drawn from two reports from OCCRI: the 2010 Oregon Climate Assessment Report (OCCRI 2010) and the 2013 Northwest Climate Assessment Report (Dalton *et al.* 2013), both found at http://occri.net/reports. This section is not meant to be a comprehensive assessment of climate change and impacts in Oregon or an all-encompassing overview of each hazard. Rather, it presents future projections of temperature and precipitation, and describes some of the effects of such future conditions based on the frequency and magnitude of natural hazards in Oregon.

Past and Future Climate in Oregon (Mote et al, 2013)

Historical (1895-present)

The impacts of climate change in Oregon are largely driven by temperature and precipitation. Temperatures in the Pacific Northwest increased 1.3 ˚F over the historical period (1895-2011 observed period). Over the last 30 years, temperatures in Oregon have generally been above the 20th century average (Figure 2-CC-1). The average annual temperatures in all but two years since 1998 have been above the average annual temperatures for the 20th century. Within the same historical time period, annual precipitation amounts fall within the normal range of natural annual variability.

Future climate

Climate modeling is mostly performed at global to regional scales because of the computational power required. The temperature and precipitation projections relied on for this summary use data from the grid cells covering the Pacific Northwest in Global Climate Models. Since the Pacific Northwest region is relatively homogenous in its climate, Global Climate Model projections for the Pacific Northwest are relevant for planning in Oregon.

A number of research centers around the world run computerized Global Climate Models (GCMs), which provide scientists and decision makers with simulations of future global climate for comparison purposes. One such project, the Coupled Model Intercomparison Project (CMIP), involves many of these modeling centers worldwide. CMIP offers many simulations for scientists to use to assess the range of future climate projections for the globe. The latest CMIP experiment is the 5th phase of the project and is thus referred to as the CMIP5. CMIP5 simulations of the 21st century climate are driven by what are called “representative concentration pathways” (RCPs). RCPs represent the total amount of extra energy (in watts/m^2) entering the climate system throughout the 21st century and beyond.

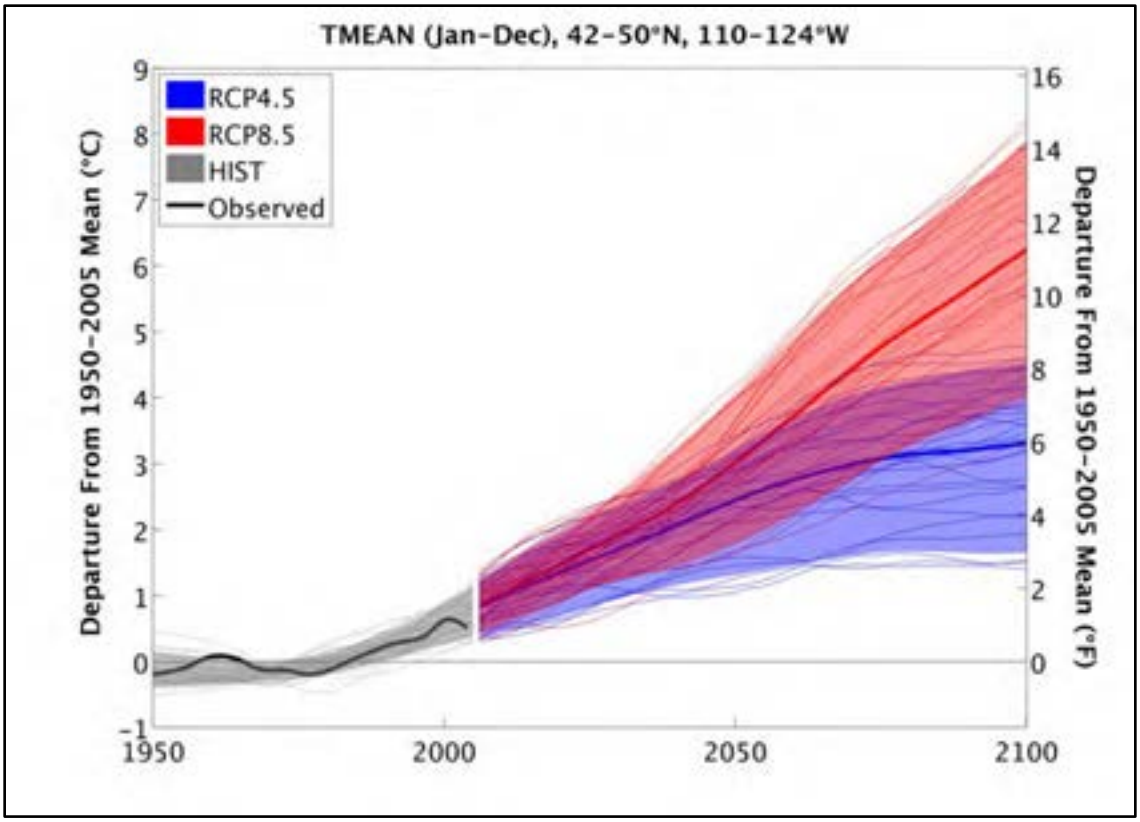

Figure 2-CC-1: Observed (1950-2011, black line) and simulated (1950-2100) regional mean annual temperature for selected GCMs for RCP 4.5 and 8.5 scenarios.

Source: Dalton et al., 2013

This summary and the Pacific Northwest section of the National Climate Assessment use scenarios RCP 4.5, which represents a significant reduction in global greenhouse gases; and RCP 8.5, which represents increasing greenhouse gases over time. Figure 2-CC-1 shows observed mean global temperatures from 1950 to 2011, and simulated mean temperatures under the two different RCPs from 2011 to 2100. Note that the projected temperature trends under different RCPs generally track closely until about 2030 or so, and they dramatically diverge after 2050.

Seasonality

Some of the most relevant climate data for planning purposes, and the most crucial to some of the hazards addressed in this plan, are seasonal projections of temperature, seasonal projections of precipitation, and change in extreme precipitation events (Tables 2-CC- 2, 3 and 4).

Tables 2-CC-2 and 3 below summarize a lot of information drawn from analyses of CMIP5 data[1]. Table 2-CC-2 contains the maximum, mean, and minimum projected changes in Pacific Northwest temperatures

[1] In this and the following discussions about Tables 1and 2, the maximum, mean, and minimum values represent the maximum model projection, the multi-model mean, and the minimum model projection.

from historical (1950-1999) to mid-21st century (2041-2070), using both RCP 4.5 and RCP 8.5 scenarios. Projected changes are shown annually and for each season.

Every climate model shows an increase in temperature for the Pacific Northwest, with the magnitude of the increase depending on rate or magnitude of global greenhouse gas emissions. *There is no plausible scenario in which the Pacific Northwest cools in the next century*. New models project an increase by mid-century (2041-2070) in annual temperatures in the PNW of 2.0°F to 8.5°F over the recent past (1970-1999). The lower projection is possible only if greenhouse gas emissions are significantly reduced (Figure 2-CC-2, RCP4.5 scenario). Both scenarios show a similar amount of warming through about 2040, meaning that temperatures beyond 2040 depend on global greenhouse emissions occurring now (Mote et al. 2013).

Of particular note in Table 2-CC-2 is that both scenarios (for RCP 4.5 and RCP 8.5) show increased average temperatures for the year *and for every season*. All models are in agreement that each season will be warmer in the future, and that the largest amount of warming will occur in the summer. Increased average winter temperatures will result in less snowpack in Oregon. Increased summer temperatures have the potential to increase the potential for wildfires and increase health-threats from poor air quality conditions and the potential for heat waves.

Table 2-CC-2: Projected change in average temperatures (maximum, mean, and minimum) for two scenarios, from last half of 20th to mid-21st centuries, in degrees Celsius

Time Period	Annual		Winter (J, F, M)		Spring (A, M, J)		Summer (J, A, S)		Fall (O, N, D)	
Scenario	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**
Maximum change	3.7°	4.7°	4.0°	5.1°	4.1°	4.6°	4.1°	5.2°	3.2°	4.6°
Mean change	2.4°	3.2°	2.5°	3.2°	2.4°	3.0°	2.6°	3.6°	2.2°	3.1°
Minimum change	1.1°	1.7°	0.9°	1.3°	0.5°	1.0°	1.3°	1.9°	0.8°	1.6°

Source: Dalton et al. 2013

Table 2-CC-3 contains a summary of projected change, *in percent*, in average precipitation for the Pacific Northwest (maximum, mean, and minimum) from historical (1950-1999) to mid-21st century (2041-2070), under both RCP 4.5 and RCP 8.5 scenarios. Projected changes are shown annually and for each season.

Note in the "Annual" columns in Table 2-CC-3 that precipitation amounts are projected to remain within the range of current natural variability. However, Table 2-CC-3 also shows that there is some indication from climate models that summers will be drier in the future.

Table 2-CC-3: Projected changes in average precipitation (maximum, mean and minimum) for two scenarios, from last half of 20th to mid-21st centuries, in percent										
Time Period	**Annual**		**Winter (J, F, M)**		**Spring (A, M, J)**		**Summer (J, A, S)**		**Fall (O, N, D)**	
Scenario	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**
Maximum change	10.1	13.4	16.3	19.8	18.8	26.6	18	12.4	13.1	12.3
Mean change	2.8	3.2	5.4	7.2	4.3	6.5	-5.6	-7.5	3.2	1.5
Minimum change	-4.3	-4.7	-5.6	-10.6	-6.8	-10.6	-33.6	-27.8	-8.5	-11

Source: Dalton et al. 2013

Extreme Precipitation

Natural hazards are often an expression of extreme conditions—wind storms, rain storms, floods, droughts, and so on. Extreme precipitation is perhaps the most common and widespread natural hazard in Oregon. Many people may associate extreme rainfall events almost exclusively with western Oregon, but in fact extreme precipitation events occur across the entire state.

Projected future changes in extreme precipitation are less ambiguous (Table 2-CC-4) than changes in total seasonal precipitation. The North American Regional Climate Change Assessment Program (NARCCAP) results indicate increases throughout the Northwest in the number of days above every threshold. Table 2-CC-4 shows the projected *percent change* in the number of days when rainfall will exceed thresholds of one, two, three, and four inches.[2] These projections (which are based on different models from those summarized in Tables 2-CC-2 and 3) show there will likely be an increase in extreme events of several different magnitudes. Note that the higher magnitude events show the largest overall increase. Note that although the frequency of extreme events rises in percentage with the magnitude of the extreme, the standard deviation rises faster. In other words, only modest events (>2.5 cm or 1 inch) increase by much more than one standard deviation (Mote et al 2013).

[2] Table 3 summarizes data from the North American regional Climate Change Assessment Program (NARCCAP). See http://www.narccap.ucar.edu/. NARCCAP is a multi-institution regional modeling effort with a coordinated approach similar to CMIP, described above.

Table 2-CC-4: Change in the number of days with extreme precipitation (from mid-century (2041-2070) minus historical (1971-2000)) over four thresholds, in percent[3]; and Standard Deviation		
	NARCCAP mean change	**NARCCAP standard deviation**
Change in the number of days with precipitation ***over one inch***	+13%	7%
Change in the number of days with precipitation ***over two inches***	+15%	14%
Change in the number of days with precipitation ***over three inches***	+22%	22%
Change in the number of days with precipitation ***over four inches***	+29%	40%

Source: Dalton et al. 2013

Effect of Oregon's Future Climate Conditions on Natural Hazards

In 2010, Oregon achieved a significant milestone in the release of two reports for two important initiatives that developed in parallel, and both addressed climate change across the state. In November 2010, OCCRI released the Oregon Climate Assessment Report (OCCRI, 2010), the first ever comprehensive scientific assessment of climate change in Oregon. At the same time, the state released the Oregon Climate Change Adaptation Framework, representing the efforts of over a dozen state agencies and institutes, including OCCRI, to begin to establish a rigorous framework for addressing the effects of climate change across the state. More recently, the 2010 Oregon Climate Assessment Report was updated by the 2013 Northwest Climate Assessment Report, also produced by OCCRI. The framework, however, has not been updated since its release in 2010.

Development of Oregon's Climate Change Adaptation Framework was significant in that the state began to address the need to plan for the effects of future climate conditions. Furthermore, Oregon's framework is the first state-level adaptation strategy based on *climate risks* as opposed to *affected sectors*. Oregon's framework lays out eleven climate risks that are of concern to the state. The risks provide a consistent basis for agencies and communities to review plans and decisions to identify measures to reduce those risks. Many of the risks in the Oregon Framework are natural hazards.

Following is a summary of the principal effects of changing climate conditions on the natural hazards addressed in the Oregon NHMP. Hazards are discussed together where the climate changes and drivers are essentially the same. How each hard (or group of hazards) affects each of the eight Oregon Office of Emergency Management (OEM) Hazard Mitigation Regions is then summarized. See Figure 2-CC-2 for the location of these regions.

[3] Values calculated at gridpoint, then averaged.

Relationship between Adaptation Framework *Risks* and *Hazards* in the Oregon NHMP

What is contained in Table 2-CC-5: The leftmost column contains the climate *risks* in the Oregon Climate Change Adaptation Framework. Column headings show natural hazards identified in the Oregon Natural Hazard Mitigation Plan.

How to read this table: Cells with an 'x' or 'X' show which *climate risks* will affect the frequency, intensity, magnitude or duration of which *natural hazards*. A big 'X 'shows a primary relationship between the risk and the hazard. A small 'x' shows a secondary relationship. The green cells in the body of the table show where an Adaptation Framework *risk* and a natural hazard in the Oregon NHMP are essentially the same thing.

Note that the first two risks—increased temperatures and changes in hydrology—are *the primary climate drivers* for natural hazards. The other climate risks represent known environmental or ecosystem responses to one or both of the primary drivers. Note also that a clear link has not been established between climate change and the frequency or intensity of wind storms.

Table 2-CC-5: Relationship between Adaptation Framework *Risks* and *Hazards* in the Oregon NHMP

	NHMP hazards								
Adaptation Framework climate risks	**Coastal erosion**	**Droughts**	**Dust storms**	**Fire**	**Flood/ CMZ**	**Landslides**	**Wind storms**	**Winter storms**	**Heat wave[4]**
Increased temperatures	x	X	x	X					X
Changes in hydrology		X	x		X	X			
Increased wildfires		x	x	X	x	x			
Increase in ocean temperatures and changes in ocean chemistry	X				x			X	
Increased drought		X		X					
Increased coastal erosion	X					x			
Changes in habitat									
Increase in invasive species and pests		x		X					
Loss of wetland ecosystems and services		X	X		X				
Increased frequency of extreme precipitation events and flooding					X	X		x	
Increased landslides						X			

[4] Heat waves are not identified as a natural hazard in the current natural hazard mitigation plan.

Figure 2-CC-2: OEM Hazard Mitigation Regions

Coastal Erosion and Coastal Flooding.

Regions affected: 1, 2.

Oregon's ocean shoreline is constantly subject to the dynamic and powerful forces of the Pacific Ocean, and it changes at timescales that vary from days to decades. Variable and changing ocean conditions continuously reshape the ocean shoreline, particularly where the shore is comprised primarily of sand. Sand levels on Oregon's beaches generally experience an annual cycle of erosion through winters and rebuilding in summer months. Over any extended time period, sandy beaches and shores will build out and retreat several times, due in part to the effects of winds, storms, tides, currents and waves. These cycles can occur over decades. In the annual cycle, beach profiles do not always recover to the heights and extent of previous years. In recent years, sand levels have remained fairly low at many locations on the Oregon coast.

The shape of Oregon's ocean shoreline is a function in part of ocean water levels and wave heights. Ocean water levels are also a primary factor in the frequency of flooding around the fringes of Oregon's estuaries. In other words, erosion of the ocean shore is directly affected by sea levels and wave heights. Flooding on the estuarine fringe is affected by ocean water levels—including tides and storm surges—in addition to freshwater inflow from the estuarine watershed. Other factors influence coastal erosion, but sea levels and wave heights are the primary climate-related drivers that influence rates of coastal erosion.

Recent studies make it clear that global ocean water levels are rising. Global sea levels are projected to rise 8-23 cm by 2030 and 18-48 cm by 2050 (NRC 2012). In Oregon (as elsewhere)

the rates of *relative* sea level rise are not the same as rates of change in global sea levels, because of a number of factors related to ocean conditions and vertical movement of the land. Oregon's western edge is rising, so the rates of sea level rise in Oregon are not as high as rates seen in other west coast locations. But even after factoring in local conditions, sea levels along Oregon's coast are rising. For more information on coastal erosion and see level rise, see the Coastal Hazards section of this Plan, beginning on page 24.

Recent research also indicates that significant wave heights off Oregon are increasing. Increasing significant wave heights may be a factor in the observed increase of coastal flooding events in Oregon. During El Niño events, sea levels can rise up to about 1.5 feet (0.5 meters) higher over extended periods (seasons).

Rising sea levels and increasing wave heights are both expected to increase coastal erosion and coastal flooding.

One of the climate risks discussed in the Oregon Climate Adaptation Framework is "Increased coastal erosion and risk of inundation from increasing wave heights and storm surges." The executive summary of the Adaptation Framework provides a summary of various challenges associated with increased coastal erosion:

> *Increased wave heights, storm surges, and sea levels can lead to loss of natural buffering functions of beaches, tidal wetlands, and dunes. Accelerating shoreline erosion has been documented, and is resulting in increased applications for shore protective structures. Shoreline alterations typically reduce the ability of beaches, tidal wetlands, and dunes to adjust to new conditions.*
>
> *Increasing sea levels, wave heights and storm surges will increase coastal erosion and likely increase damage to private property and infrastructure situated on coastal shorelands. Coastal erosion and the common response to reduce shoreland erosion can lead to long-term loss of natural buffering functions of beaches and dunes. Applications for shoreline alteration permits to protect property and infrastructure are increasing, but in the long term they reduce the ability of shore systems to adjust to new conditions.*

Drought, Wildfire, and Dust Storms.

Regions affected: 1-8

All eight regions in the Oregon NHMP are potentially affected by increasing incidence of drought and wildfire. Moreover, areas that have historically been both hotter and drier than the statewide average—southwest Oregon counties and central and eastern Oregon—are at somewhat higher risk of increased drought and wildfire than the state overall.
There is no current research available on the direct effects of future climate conditions on the incidence of dust storms. However, because drought conditions have the effect of reducing wetlands and drying soils, droughts can increase the amount of soil particulate matter available to be entrained in high winds, in particular where agriculture practices include tilling. This correlation between drought conditions and dust storms means that an increase in future

droughts could increase the incidence of dust storms, even though the drought is unrelated to the storm.

Droughts, fires, and dust storms are addressed as separate hazards in this plan. However, the underlying climate mechanism is similar for each. These hazards all occur in conjunction with warmer and drier conditions.

Virtually all climate models project warmer, drier summers for Oregon, with mean projected seasonal increases in summer temperatures of 2.6 to 3.6 ˚C by mid-century, and a decline in mean summer precipitation amounts of 5.6 to 7.5 percent by mid-century. These summer conditions will be coupled with by projected decreases in mountain snowpack due to warmer winter temperatures. Models project a mean increase in winter temperatures of 2.5 to 3.2 ˚C by mid-century. This combination of factors exacerbates the likelihood of drought, which in turn often leads to an increase in the incidence and likelihood of wildfires and dust storms.

Two climate risks that are somewhat prominent in the framework are "Increase in wildfire frequency and intensity" and "Increased incidence of drought." Dust storms were not addressed in the framework as a climate risk; at the time the framework was developed, research literature on the climatic conditions behind dust storms was scarce or nonexistent.
The executive summary of Oregon's Climate Change Adaptation Framework provides a summary of challenges associated with increased incidence of both wildfires and drought, as follows.

Wildfire
Increased temperatures, the potential for reduced precipitation in summer months, and accumulation of fuels in forests due to insect and disease damage (particularly in eastside forests[5]) present high risk for catastrophic fires. An increase in frequency and intensity of wildfire will damage larger areas, and likely cause greater ecosystem and habitat damage. Larger and more frequent wildfires will increase human health risks due to exposure to smoke.

Increased risk of wildfire will result in increased potential for economic damage at the urban-wildland interface. Wildfires destroy property, infrastructure, commercial timber, recreational opportunities, and ecosystem services. Some buildings and infrastructure subject to increased fire risk may not be adequately insured against losses due to fire. Increased fire danger will increase the cost to prevent, prepare for, and respond to wildfires.

Drought

Longer and drier growing seasons and drought will result in increased demand on ground water resources and increased consumption of water for irrigation, which will have potential consequences for natural systems. Droughts affect wetlands, stream systems, and aquatic habitats. Drought will result in drier forests and increase likelihood of wildfire.

[5] Forests east of the crest of the Cascade Range.

Droughts will cause significant economic damage to the agriculture industry through reduced yields and quality of some crops. Droughts can increase irrigation-related water consumption, and thus increase irrigation costs. Drought conditions can also have a significant effect on the supply of drinking water.

Winter Storms, Flooding, and Landslides

Regions affected: 1-4

Flooding and landslides are projected to occur more frequently throughout western Oregon, in Oregon NHMP Regions 1 through 4. While winter storms affect all areas of the state, there is no current research available indicating any change in the incidence of winter storms due to changing climate conditions.

The increase in extreme precipitation that is projected to occur at all thresholds from 1 to 4 inches per day (see Table 2-CC-4) is expected to result in a greater risk of flooding in certain basins. Changes in flood risk are strongly associated with the dominant form of precipitation in a basin, with mixed rain-snow basins in Washington and Oregon already seeing increases in flood risk. Generally, western Oregon basins are projected to experience increased flood risk in future decades. Increased flood risk involves both an increased incidence of flooding of a certain magnitude and an increase in the magnitude of floods of a certain return interval. In other areas of the state, flood risk may decrease in some basins and increase in others.

Landslides in Oregon are strongly correlated with rainfall, so increased rainfall— particularly in extreme events—will likely trigger increased landslides.

The executive summary of Oregon's Climate Change Adaptation Framework provides a summary of challenges associated with both flooding and landslides:

Floods:

Extreme precipitation events have the potential to cause localized flooding due partly to inadequate capacity of storm drain systems. Extreme events can damage or cause failure of dam spillways. Increased incidence and magnitude of flood events will increase damage to property and infrastructure, and will increase the vulnerability of areas that already experience repeated flooding. Areas thought to be outside the floodplain may begin to experience flooding. Many of these areas have improvements that are not built to floodplain management standards and are not insured against flood damage; therefore being more vulnerable to flood events. Finally, increased flooding will increase flood-related transportation system disruptions, thereby affecting the distribution of water, food, and essential services.

Landslides

Increased landslides will cause increased damage to property and infrastructure, and will disrupt transportation and the distribution of water, food, and essential services. Widespread damaging landslides that accompany intense rainstorms (such as

“pineapple express” winter storms) and related floods occur during most winters. Particularly high-consequence events occur about every decade; recent examples include those in February 1996, November 2006 and December 2007.

Windstorms

Regions affected: Unknown

There is little research on changing wind in the Pacific Northwest as a result of climate change.

IPCC 2013. Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

OCCRI 2010. The Oregon Climate Assessment Report, K.D. Dello and P.W. Mote (eds). College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis OR.

Dalton, M.M., P.W. Mote, A.K. Snover (eds.) 2013. Climate Change in the Northwest: Implications for Our Landscapes, Waters and Communities. Washington DC: Island Press.

Mote, P.W, J.T. Abatzoglou, K.E. Kunkel (2013). Variability and Change in the Past and Future. In Climate Change in the Northwest: Implications for Our Landscapes, Waters and Communities. Washington DC: Island Press.

Hazards

Requirement: 44 CFR §201.4(c)(2)(i): Th[e] risk assessment shall include… (i) (a)n overview of the type and location of all natural hazards that can affect the State, including information on previous occurrences of hazard events, as well as the probability of future hazard events, using maps where appropriate;

Coastal Hazards

Figure 2-CE-1: The Capes, a multi-million dollar condominium complex constructed on an old Holocene dune field adjacent to Oceanside. Due to erosion of the sand at the toe of the bluff during the 1997-98 El Nińo winter, the bluff face began to fail threatening several of the homes built nearest the bluff edge

Source: DOGAMI

The Pacific Northwest (PNW) coast of Oregon is without doubt one of the most dynamic coastal landscapes in North America, evident by its long sandy beaches, sheer coastal cliffs, dramatic headlands and vistas, and ultimately the power of the Pacific Ocean that serves to erode and change the shape of the coast. It is these qualities along with its various natural resources that have drawn people to live along its narrow shores. However, coastal communities are increasingly under threat from a variety of natural hazards, including coastal erosion (both short and long-term), landslides, earthquakes, and potentially catastrophic tsunamis generated by the Cascadia subduction zone (CSZ). Over time, these hazards are gradually being compounded, in part due to the degree of development that has evolved along the Oregon coast in recent decades (Figure 2- CE-1). A particular concern is that the local geology and geomorphology of the region have restricted development to low-lying areas, chiefly along dunes, barrier spits, or along coastal bluffs present along the open coast that are subject to varying rates of erosion, and to low-lying areas adjacent to the numerous estuaries that make up the coast. All of these sites are highly susceptible to increased impacts as erosion processes and flood hazards intensify, driven by rising sea level and increased storminess.

(Figure2- CE-2: A) Emergency riprap being placed in front of a home at Gleneden Beach, following a recent bluff failure (February 2013).

B) Homes being inundated with excess sand during a strong wind event in November 2001.

Source: DOGAMI

Beaches and coastal bluffs are some of the most dynamic landforms, responding to a myriad of variables. Both

landforms are constantly changing (at varying time scales) as they respond to changes in the ocean processes (waves, nearshore currents and tides) that affect the beach and toe of the bluff as well as those sub-aerial processes (rainfall, sun, wind) that directly affect coastal bluffs. There are many dangers inherent in living on the coast. While coastal bluffs gradually erode over the long-term, they can also respond very rapidly, at times sliding away (in a matter of minutes to a few hours) so that homes and sections of highways are damaged or destroyed (Figure2-CE-2A). Beaches are especially dynamic features, as sand is constantly shifted about. This is especially noticeable in major storms, with the shoreline retreating rapidly, periodically destroying homes built too close to the sea. At other times, large quantities of sand migrate back onto beaches, burying homes built atop coastal dunes (Figure 2-CE-2B). There is no location on the Oregon coast that is immune to coastal hazards.

Without question, the most important natural variables that influence changes to the shape and width of the beach and ultimately its stability are the beach sand budget (balance of sand entering and leaving the system) and the processes (waves, currents, tides, and wind) that drive the changes.

Human influences associated with jetty construction, dredging practices, coastal engineering, and the introduction of non-native dune grasses have all affected the shape and configuration of the beach, including the volume of sand on a number of Oregon's beaches, ultimately influencing the stability or instability of these beaches.

Analysis and Characterization

Geology and Geomorphology

The Oregon coast is 366 miles long from the Columbia River to the California border. The present coastline is the result of geologic processes that include a rise in sea level as Ice Age glaciers melted. The coastal geomorphology of this landscape reflects a myriad of geomorphic features (Figure 2-CE-3) that range from plunging cliffs (in regions 1, 4, & 5), rocky shorelines and shore platforms (regions 1, 3, 5, & 6), wide and narrow sandy beaches backed by both dunes (regions 2, 5 & 6) and cliffs (regions 3 & 4), gravel and cobble beaches backed by cliffs (regions 1, 5 & 6), barrier spits (regions 2, 4 & 5), and estuaries (regions 1-6). Cliffed or bluff-backed shorelines make up the bulk of the coast accounting for 58% of the coastline, the remainder being dune-backed. Geomorphically, the coast can be broken up into a series of "pocket beach" littoral cells (Figure 2-CE-3) that reflect resistant headlands (chiefly basalt) interspersed with short to long stretches of beaches backed by both less resistant cliffs and dunes (e.g. Lincoln and Tillamook Counties (regions 3 & 5 in Figure 2-CE-4). The headlands effectively prevent the exchange of sand between adjacent littoral cells. Some beaches form barrier spits, creating estuaries or bays behind them (e.g. Netarts, Nestucca and Siletz Spits). About 75.6% of the coastline consists of beaches comprised of sand or gravel backed by either dunes or bluffs, while the remaining 24.4% of the

Figure 2-CE-3: The coastal geomorphology of the Oregon coast, including a break-down of Oregon littoral cells. Bold black lines denote the locations of cliffs and rocky shores. Faint grey lines denote faulting. Numbers indicate regional coastal geomorphic features: plunging cliffs (1, 4 & 5), rocky shorelines and shore platforms (1, 3, 5 & 6), wide and narrow sandy beaches backed by both dunes (2, 5 & 6) and cliffs (3 & 4), gravel and cobble beaches backed by cliffs (1, 5 & 6), barrier spits (2 & 5), and estuaries (1-6)

Source: DOGAMI

coast is comprised of a mixture of rocky cliffs (including headlands) and shores. Of the 18 littoral cells on the Oregon coast, the largest is the Coos cell, which extends from Cape Arago in the south to Heceta Head in the north, some 62.6 miles in length.

Interspersed among the littoral cells are 21 estuaries that range in size from small, such as the Winchuck estuary (0.5 km^2) adjacent to the Oregon/California border, to large, such as the Columbia River (380 km^2), which separates the states of Oregon and Washington. The estuaries are all ecologically important to many fish and wildlife species and in many cases are the sites of important recreational and commercial enterprise. In general, Oregon estuaries can be divided into two broad groups based on physiographic differences between estuaries located on the north and south coast. On the northern Oregon coast, the prevalence of pocket beach littoral cells and weaker rock formations in the coast range has resulted in more rapid erosion of the region's rock formations. This produces ample material at the coast, and coupled with alongshore sediment transport, has aided the formation of barrier spits across drowned river valleys and hence estuaries. In contrast, sediment loads on the southern Oregon coast are comparatively lower due to there being more resistant rock formations. Furthermore, the region is generally much steeper, which essentially limits the landward extent of the tide in drowned rivers and hence, ultimately the size of the estuaries.

Figure 2-CE-4: A) Houses line the cliff at Fogarty Creek in Lincoln County. Note the proximity of the eroding cliff edge to the homes.

B) Extensive erosion along the dune-backed beaches in Neskowin have resulted in the construction of massive riprap structures (solid bold line), which now essentially protect the entire community from further erosion

Source: L. Stimely, DOGAMI.

Unlike much of the U.S. coast, population pressure on the Oregon coast is relatively low and is largely confined to small coastal towns separated by large tracts of coast with little to no development. The bulk of these developments are concentrated on the central to northern Oregon coast in Lincoln, Tillamook and Clatsop Counties. On the cliffed shores of the central Oregon coast (Figure 2-CE-4A), between Newport and Lincoln City, homes are perched precariously close to the edge of the cliffs and in some areas the erosion has become acute requiring various forms of coastal engineering (commonly riprap) in order to mitigate the problem (Figure 2-CE-4B), and in a few cases the landward removal of the homes. In other areas, critical infrastructure such as U.S. Highway 101 track close to the coast and in a few areas, erosion of the cliffs has resulted in expensive remediation (e.g. adjacent to Nesika Beach in

Curry County). While the processes driving coastal erosion on bluff-backed shores are entirely a function of the delicate balance between the assailing forces (waves, tides, and currents) and properties of the rock (rock type, bedding, strength, etc.), increasing development pressure, weak land-use regulations, a lack of quantitative information, and ignorance of the physical processes have certainly contributed to the need for remediation in many coastal areas.

Elsewhere, significant development is typically located along the seaward most dune (foredune) system (Figure 2-CE-2B and 5B), as developers seek to capitalize on ocean views and proximity to the beach. However, major storms, especially in the late 1990s have resulted in extensive erosion, with many communities (e.g. Neskowin and Rockaway Beach in Tillamook County) having to resort to major coastal engineering in order to safeguard individual properties. The magnitude and extent of these erosion events have now left entire communities entirely dependent on the integrity of the structures.

Sand Budget

The beach sand budget is the rate at which sand is brought into the coastal system versus the rate at which sand leaves the system. A negative balance means that more sand is leaving than is arriving and results in erosion of that segment of shoreline. A positive balance means that more sand is arriving than is leaving, enabling that segment of shoreline to gain sand and accrete and potentially advance seaward. Along the Oregon coast, potential sources of sand include rivers, bluffs, dunes, and the inner shelf. Potential sand sinks include, bays (estuaries), dunes, dredging around the mouths of estuaries, and mining of sand.

Attention is often focused on the effects of beach and dune erosion. Yet, there are segments of Oregon's coast where periodically the concern is excess sand build-up, as has occurred in places like Pacific City (Figure 2-CE-2B), Manzanita, Bayshore Spit, Nedonna and Cannon Beach.

Classifying Coastal Hazards

Natural hazards that affect coastal regions can be divided into two general classes, *chronic* and *catastrophic*:

> Chronic hazards are those we can see clear evidence of along the shore: beach, dune, and bluff erosion, landslides, slumps, and flooding of low-lying lands during major storms. The damage caused by chronic hazards is usually gradual and cumulative. However, storms that produce large winter waves, heavy rainfall and/or high winds may result in very rapid erosion or other damage that can affect properties and infrastructure over a matter of hours. The regional, oceanic, and climatic environments that result in intense winter storms determine the severity of chronic hazards along the Oregon coast. Chronic hazards are typically local in nature, and the threats to human life and property that arise from them are generally less severe than those associated with catastrophic hazards. However, the wide distribution and frequent occurrence of chronic hazards makes them a more immediate concern.
>
> Catastrophic hazards are regional in scale and scope. Cascadia Subduction Zone earthquakes, and the ground shaking, subsidence, landsliding, liquefaction, and tsunamis that accompany them are catastrophic hazards. Tsunamis generated from distant earthquakes can also cause substantial damage in some coastal areas. The processes associated with earthquakes, tsunamis, floods, and landslides are discussed later in this chapter.

Causes of Coastal Hazards

Chronic coastal hazards include periodic high rates of beach and dune erosion, sand inundation, "hotspot erosion" due to the occurrence of El Niños and from rip current embayments, intermittent coastal flooding as a result of El Niños, storm surges and high ocean waves, and the enduring recession of coastal bluffs due to long-term changes in mean sea level, variations in the magnitude and frequency of storm systems, and climate change. Other important hazards include mass wasting of sea cliffs such as slumping and landslides, which may be due to wave attack and geologic instability.

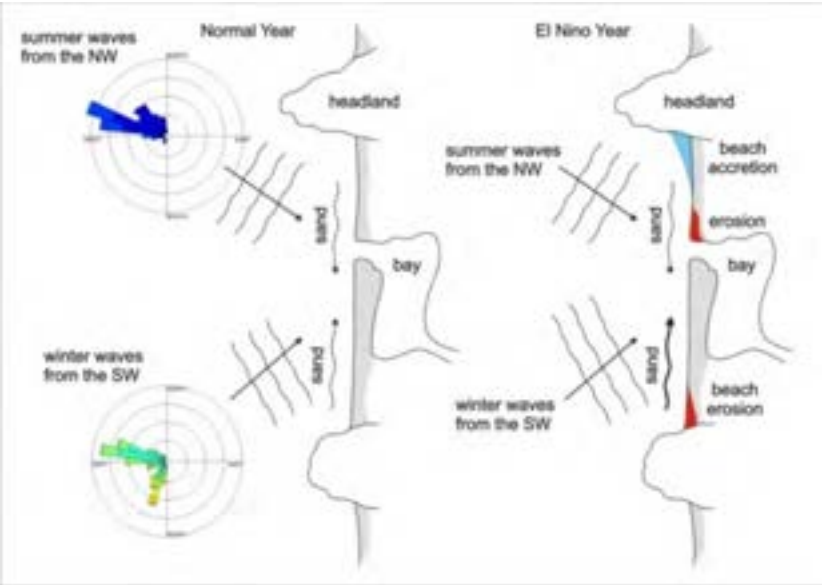

Figure CE-5: Patterns of sediment transport during "normal" and El Nino years

Source: Komar, 1986.

Most of these hazards are the product of the annual barrage of rain, wind, and waves that batter the Oregon coast, causing ever-increasing property damage and losses. A number of these hazards may be further exacerbated by climate cycles such as the El Niño Southern Oscillation, or longer-term climate cycles associated with the Pacific Decadal Oscillation. Other hazards, such as subduction zone earthquakes and resulting tsunamis, can have catastrophic impacts on coastal communities' residents and infrastructure, and in many areas these impacts will persist for many decades following the event due to adjustments in the coastal morphodynamics following subsidence or uplift of the coast. All of these processes can interact in complex ways, increasing the risk from natural hazards in coastal areas.

Waves

Along dune- and bluff-backed shorelines, waves are the major factor that affect the shape and composition of beaches. Waves transport sand onshore (towards the beach), offshore (seaward to form nearshore bars etc.), and along the beach (longshore transport). Short-term beach and shoreline variability (i.e. storm related changes) is directly dependent on the size of the waves that break along the coast, along with high ocean water levels, and cell circulation patterns associated with rip currents. In contrast, long-term shoreline changes is dependent on the balance of the beach sediment budget, changes in sea level over time, and patterns of storminess.

The Oregon coast is exposed to one of the most extreme ocean wave climates in the world, due to its long fetches and the strength of the extratropical storms that develop and track across the North Pacific. These storms exhibit a pronounced seasonal cycle producing the highest waves (mean = 12.8 ft) in the winter, with winter storms commonly generating deep-water wave heights greater than 33 ft, with the

largest storms in the region having generated waves in the range of 45 to 50 ft. In contrast, summer months are dominated by considerably smaller waves (mean = 5.3 ft), enabling beaches to rebuild and gain sand eroded by the preceding winter. When large waves are superimposed on high tides, they can reach much higher elevations at the back of the beach, contributing to significantly higher rates of coastal erosion and flood hazards. It is the combined effect of these processes that leads to the erosion of coastal dunes and bluffs, causing them to retreat landward.

Winds and waves tend to arrive from the southwest during the winter and from the northwest during the summer. Net sand transport tends to be offshore and to the north in winter and onshore and to the south during the summer (Figure 2-CE-5). El Niño events can exaggerate the characteristic seasonal pattern of erosion and accretion, and may result in an additional 60–80 feet of "hotspot" dune erosion along the southern ends of Oregon's littoral cells, particularly those beaches that are backed by dunes, and on the north side of estuary inlets, rivers and creeks.

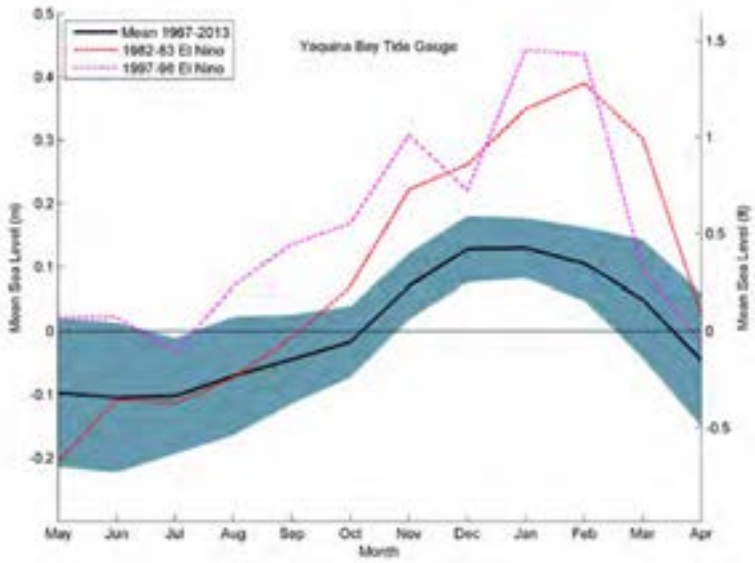

Figure 2-CE-6: Average monthly tides for the Yaquina Bay tide gage (± 1 standard deviation (shaded region) providing a measure of normal ranges) expressed as an average for the period 1967-2013, and as monthly averages for the 1982-83 and 1997-98 El Niños.

Source: DOGAMI

Ocean Water Levels

The elevation of the sea is controlled in part by the astronomical tide. High ocean water levels at the shoreline may be the product of combinations of high tides, storm surges, strong onshore-directed winds, El Niños and wave runup. As can be seen in Figure 2-CE-6, the Oregon coast experiences a seasonal cycle in its measured tides, with the tides tending to be highest in the winter and lowest in the summer. This seasonal variation is entirely a function of ocean upwelling during the summer months, which brings cold dense water to the surface and due to the Coriolis effect and ocean currents, this water is directed landward where it piles up along the coast depressing sea level. In the winter this process breaks down resulting in a warming of the ocean, which raises the mean sea level. The typical seasonal variability in water levels is ~0.8 ft, increasing to as much as 2 ft during an El Nińo (Figure 2-CE-6), essentially raising the mean shoreline elevation, enabling waves to break closer to dunes or along the base of coastal bluffs.

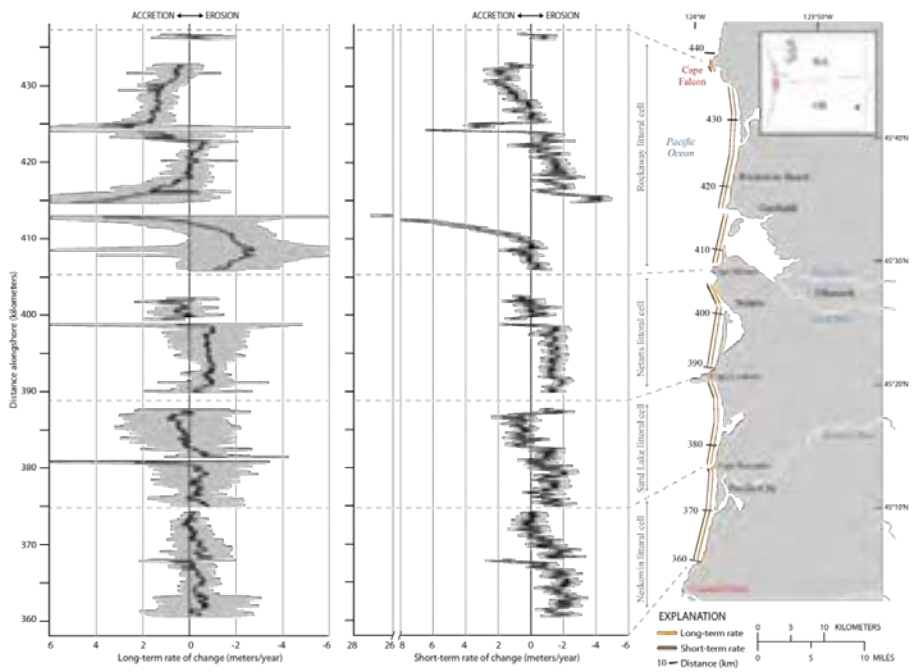

Figure 2-CE-7: Plots showing long- and short-term shoreline change rates calculated for the Tillamook County region.

Source: Ruggiero et al., in press

Shoreline Changes

Dune-backed beaches respond very quickly to storm wave erosion, sometimes receding tens of feet during a single storm and hundreds of feet in a single winter season. Beach monitoring studies undertaken by DOGAMI staff (http://nvs.nanoos.org/BeachMapping) have documented storm induced erosion of 30 – 60 ft from single storm events, while seasonal changes may reach as much as 90-130 ft on the dissipative, flat, sandy beaches of Oregon, and as much as 190 ft on the more reflective, steeper beaches of the south coast (e.g. adjacent to Garrison Lake, Port Orford). Furthermore, during the past 15 years a number of sites on the northern Oregon coast (e.g. Neskowin, Netarts Spit and Rockaway Beach) have experienced considerable erosion and shoreline retreat. For example, erosion of the beach in

Neskowin has resulted in the foredune having receded landward by as much as 150 ft since 1997. South of Twin Rocks near Rockaway, the dune has eroded ~140 ft over the same time period. Continued monitoring of these study sites are now beginning to yield enough data from which trends (erosion or accretion rates) may be extrapolated. These latter datasets are accessible via the web (http://nvs.nanoos.org/BeachMapping).

Recently, studies undertaken by the USGS provide additional insights into the spatial extent of erosion patterns on the Oregon coast. Figure 2-CE-7 provides analyses of both long-term (~1900s to 2002) and short-term (~1960s/80s to 2002) shoreline change patterns along the Tillamook County coast, confirming measured data reported by DOGAMI. As can be seen from the figure, long-term erosion rates (albeit low rates) dominate the bulk of Tillamook County (i.e. Bayocean Spit, Netarts, Sand Lake, and Neskowin littoral cells), while accretion prevailed in the north along Rockaway Beach and on Nehalem Spit. The significant rates of accretion identified adjacent to the mouth of Tillamook Bay are entirely due to construction of the Tillamook jetties, with the north jetty completed in 1917 and the south jetty in 1974. Short-term shoreline change patterns indicate that erosion has continued to dominate the bulk of the shoreline responses observed along the Tillamook County coast. Erosion is especially acute in the Neskowin, Sand Lake and Netarts littoral cells, and especially along Rockaway Beach. In many of these areas, the degree of erosion remains so significant, that were we to experience a major storm(s) in the ensuing winters, the risk of considerable damage to property and infrastructure in these areas would likely be high.

Figure 2-CE-8: Map showing Alsea Bay spit erosion as a result of the 1982-83 El Nińo (left), and state of the beach in 2009 (right). Yellow/black line delineates a riprap structure constructed to protect the properties from further erosion. Orange line defines the maximum extent of dune erosion due to wave attack as a result of the 1982-83 event. Note the northward migration of the estuary mouth compared to its position in 2009.

Source: DOGAMI

The processes of wave attack significantly affect shorelines characterized by indentations, known as inlets. Waves interact with ocean tides and river forces to control patterns of inlet migration. This is especially the case during El Niño's. During an El Niño, large storm waves tend to arrive out of the south, which causes the mouth of the estuary to migrate to the north, where it may abut against the shoreline, allowing large winter waves to break much closer to the shore. This can result in significant "hotspot" erosion" north of the estuary mouth. Recent examples of the importance of inlet dynamics during an El Niño are Alsea Spit near Waldport (Figure 2-CE-8), Netarts Spit near Oceanside, and at Hunter Creek on the southern Oregon coast at Gold Beach.

Floods

Flood Insurance Rate Maps (FIRMs) and Flood Insurance Studies (FISs)are also often used in characterizing and identifying flood-prone areas. FEMA conducted many FISs in the late 1970s and early 1980s. Included were "VE" zones, areas subject to wave action and ocean flooding during a "100-year" event that encompass the area extending from the surfzone to the inland limit of wave runup, and/or wave overtopping and inundation, and or the location of the primary frontal dune or any other area subject to high velocity wave action from coastal storms. Areas identified as VE zones are subject to more development standards than other flood zones. Currently, DOGAMI is working with FEMA to update and remap FEMA coastal flood zones established for coastal communities along the Oregon coast.

Landslides

Simple surface sloughing is the dominant process along bluff-backed shorelines. Other shorelines are backed by steep slopes, where deep-seated landslides and slumping are the dominant processes (Figure 2-CE-1). The geologic composition of the bluff is a primary control on slope stability.

Headlands, generally composed of basalt, are more resistant to erosion and do not readily give way. In contrast, soft bluff-forming sandstone and mudstone are highly susceptible to slope movement. Prolonged winter rains saturate these porous bluff materials, increasing the likelihood of landslides.

The geometry and structure of bluff materials also affect slope stability by defining lines of weakness and controlling surface and subsurface drainage. As waves remove sediment from the toe of the bluff, the bluffs become increasingly vulnerable to slope failure due to increased exposure to wave attack. The extent to which the beach fronting the bluff acts as a buffer is thus important in this regard. Thus a reduction in the sand beach volume in front of a bluff increases its susceptibility to wave erosion along its toe, which can eventually contribute to the failure of the bluff.

Figure 2-CE-9: Bluff failure due to toe erosion by ocean waves resulted in the top of the bluff eroding landward by ~30 ft over a 48 hour period in November 2006.

Photo source: OPDR

A recent example of such a process occurred at Gleneden Beach in Lincoln County in November 2006 (Figure 2-CE-9), when a large rip current embayment (an area of the beach that exhibits more erosion and beach narrowing due to removal of sand by rip currents) formed in front of a portion of the bluff, allowing waves to directly attack the base of the bluff. In a matter of two days, the bluff eroded back by up to 30 ft, undermining the foundation of two homes, almost resulting in to their destruction.

Similar processes occurred nearby during the 1972/73 winter, which led to one home having to be pulled off its foundation. Both examples provide a stark reminder of the danger of building too close to the beach and that these types of changes do occur relatively frequently.

Climate Change and Sea Level Rise

An understanding of the trends and variations in sea level on the Oregon coast provides important insights as to the spatial patterns of erosion and flood hazards. In general, tectonic uplift is occurring at a much faster rate (~2-4 mm/year) on the south coast (south of about Coos Bay), while the uplift rates on the central to northern Oregon coast are much lower, averaging about 1 mm/year (Figure 2-CE-10, left). When combined with regional patterns of sea level change (Figure 2-CE-10, right), it is apparent that the southern Oregon coast is essentially an emergent coast, with the coast rising at a much faster rate when compared with sea level. In contrast, the central to northern Oregon coast is a submergent coast due to the fact that sea level is rising faster than the land. Not surprisingly, it is the north coast that exhibits the most pervasive erosion and flood hazards when compared with the south coast.

In 2012, the National Research Council completed a major synthesis of the relative risks of sea level rise on the US West Coast. The consensus from that report is that sea level has risen globally by on average 1.7 mm/year, while rates derived from satellite altimetry indicate an increase in the rate of sea level rise to 3.2 mm/year[6] since 1993. Combining our knowledge of glacial isostatic rebound (the rate at which the earth responds to the removal of ice from the last glaciations), regional tectonics, and future temperature patterns, the committee concluded that sea level on the Oregon coast would increase by approximately 2.1 ft by 2100.

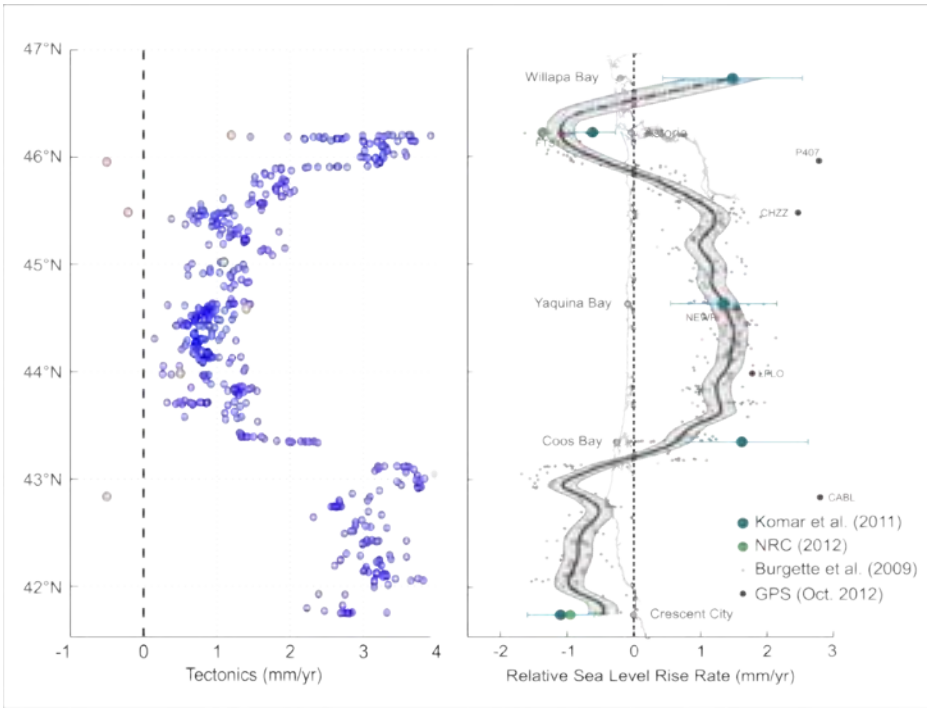

Figure 2- CE-10: (Left) Along coast variations in rates of tectonic uplift, and (Right) Relative sea level trends for the Oregon coast.

[6] Source: After Komar et al., 2011. Website: http://www.aviso.oceanobs.com/en/news/ocean-indicators/mean-sea-level/

2030 Projection	Range	2050 Projection	Range	2100 Projection	Range
0.2 ft	-0.1 – 0.7 ft	0.6 ft	-0.07 – 1.6 ft	2.1 ft	0.4 – 4.7 ft

Table 2-CE-1: Projected sea level rise for the central Oregon coast

Source: NRC, 2012.

Table 2-CE-1 presents the NRC (2012) projected sea level rise findings for the Central Oregon coast. The largest increase in regional sea level is estimated to be 4.7 ft by 2100. Of importance, these projections assume that sea level is uniform year round. However, as noted previously, sea level on the Oregon coast exhibits a pronounced seasonal cycle of about 0.8 ft between summer and winter, increasing to as much as 2 ft in response to the development of a strong El Nińo. Thus, when combined with projected future increases in regional sea level, it becomes apparent that the potential increase in mean sea level could be substantially greater depending on the time of year (Figure 2-CE-11). For example, by 2100, sea level during an El Nińo winter will have increased by a total of 6.6 ft, raising the mean shoreline position by that amount, which will have shifted upward and landward as beaches respond to the change in mean water levels. Based on these projections, it can be expected that areas presently classified as emergent (e.g. the southern Oregon coast), will become submergent over time as the rate of sea level rise surpasses tectonic uplift. Furthermore, erosion and flood hazards on the northern Oregon coast will almost certainly accelerate, increasing the risk to property.

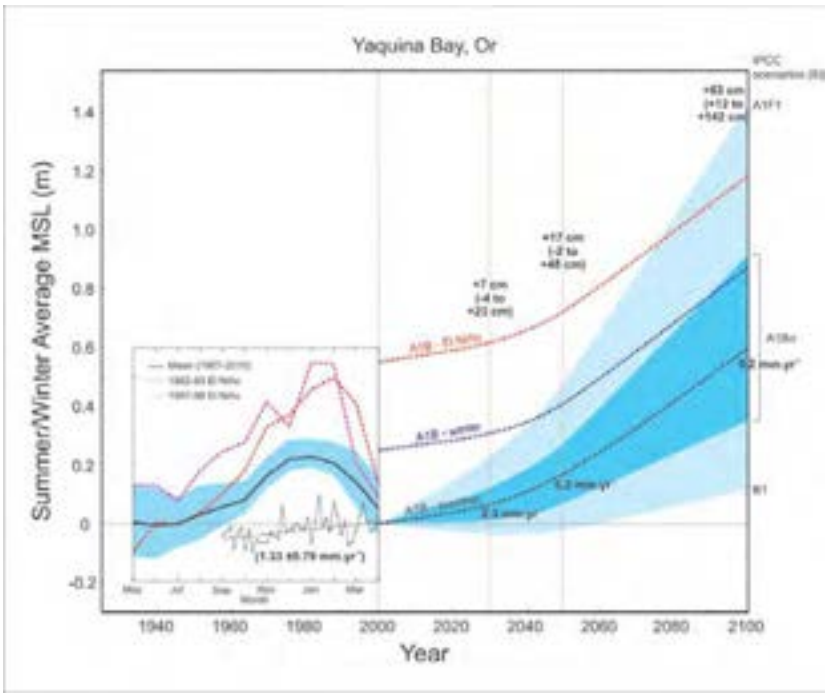

Figure 2-CE-11: Projected future changes in regional sea levels on the Oregon coast

Source: NRC, 2012.

Human Activities

Human activities affect the stability of all types of shoreline. Large-scale human activities such as jetty construction and maintenance dredging have a long-term effect on large geographic areas. This is particularly true along dune-backed and inlet-affected shorelines such as the Columbia River and Rockaway littoral cells (Figure 2-CE-3). The planting of European beachgrass (Ammophila arenaria) since the early 1900s, and more recently American beachgrass (Ammophila breviligulata) has locked up sand in the form of high dunes. Such a process can contribute to a net loss in the beach sand budget and may help drive coastal erosion.

Residential and commercial development can affect shoreline stability over shorter time periods and smaller geographic areas. Activities such as grading and excavation, surface and subsurface drainage alterations, vegetation removal, and vegetative as well as structural shoreline stabilization can all affect shoreline stability.

While site-specific coastal engineering efforts such as the construction of riprap revetments is less likely to cause direct adverse impacts to the beach, **the cumulative effect of constructing many of these structures along a particular shore** (e.g. as has occurred along the communities of Gleneden Beach, Siletz Spit, Lincoln City, Neskowin, Pacific City, and Rockaway) **will almost certainly decrease the volume of sediment being supplied to the beach system,** potentially affecting the beach sediment budget and hence the stability of beaches within those littoral cells.

Heavy recreational use in the form of pedestrian and vehicular traffic can affect shoreline stability over shorter time frames and smaller spaces. Because these activities may result in the loss of fragile vegetative cover, they are a particular concern along dune-backed shorelines. Graffiti carving along bluff-backed shorelines is another byproduct of recreational use that can damage fragile shoreline stability.

Historical Coastal Hazards in Oregon

Table 2- CE-2 lists historic coastal erosion and flood hazard events in Oregon.

Table 2-CE-2: Historic Coastal Hazard Events in Oregon

Date	Location	Description
January 1914	Newport, OR	Damage (Nicolai Hotel).
1931	Rockaway, OR	Coastal damage from December storm.
October- December 1934	Waldport and Rockaway, OR	Flooding (Waldport). Coastal damage (Rockaway Beach).
December 1935	Cannon Beach and Rockaway Beach, OR	Coastal damage.
January 1939	Coastwide, OR	Severe gale. Damage: coastwide. Severe flooding (Seaside, and Ecola Creek near Cannon Beach): • Multiple spit breaches (southern portion of Netarts Spit) • Storm damage (along the shore of Lincoln City and at D River) • Flooding (Waldport) • Extensive damage (Sunset Bay Park) • Storm surge overtopped foredune (Garrison Lake plus Elk River lowland)
December 1940	Waldport, OR	Flooding.
1948	Newport, OR	Wave damage(Yaquina Arts Center)
January 1953	Rockaway, OR	70 foot dune retreat. One home removed.
April 1958	Sunset Bay State Park, Newport, OR	Flooding (Sunset Bay); Wave damage (Yaquina Arts Center in Newport).
January- Februrary 1960	Sunset Bay State Park, OR	Flooding.
1964	Cannon Beach, OR	Storm damage.
December 1967	Netarts Spit, Lincoln City, Newport, Waldport, OR	Damage: coastwide. • State constructed wood bulkhead to protect foredune along 600 ft section (Cape Lookout State Park campground). • Flooding and logs (Lincoln City). • Wave damage (Yaquina Arts Center, Newport). • Flooding (Waldport). • Storm damage (Beachside State Park • Washed up driftwood (Bandon south jetty parking lot).

1971-73	Siletz Spit, OR	• High tide line eroded landward by 300 ft. • February 1973, one home completely destroyed. Spit almost breached. • Logs through Sea Gypsy Motel (Nov. 1973).
1982-83	Alsea Spit, OR	Northward migration of Alsea Bay mouth. Severe erosion.
1997-98	Lincoln and Tillamook Counties, OR	El Nino winter (second strongest on record). Erosion: considerable.
1999	Coastwide, OR	Five storms between January and March. Coastal erosion: extensive, including: • Significant erosion (Neskowin, Netarts Spit, Oceanside, Rockaway beach); • Overtopping and flooding (Cape Meares) • Significant erosion along barrier beach (Garrison Lake); overtopping 27ft high barrier.
December 2007	Tillamook and Clatsop Counties, OR	Wind storm.

Source: Schlicker et al. 1972; Schlicker et al. 1973; Stembridge 1975; Komar and McKinney 1977; Komar 1986, 1987, 1997, 1998; Allan et al. 2003; Allan et al. 2009, and many others.

Probability

Waves

Previous analyses of extreme waves for the Oregon coast estimated the "100-year" storm wave to be around 33 feet. In response to a series of large wave events that occurred during the latter half of the 1990s, the wave climate was subsequently re-examined and an updated projection of the 100-year storm wave height was determined, which is now estimated to reach approximately 47 to 52 feet (Table 2-CE-3), depending on which buoy is used. These estimates are of considerable importance to the design of coastal engineering structures and in terms of defining future coastal erosion hazard zones.

Recurrence Interval (*years*)	**Extreme Wave Heights** (*feet*)	
	NDBC buoy #46002* **(Oregon)**	**NDBC buoy #46005+ (Washington)**
10	42.5	41.7
25	46.2	44.0
50	48.8	-
75	50.1	45.7
100	51.2	47.1

Table 2-CE-3: Projection of extreme wave heights for various recurrence intervals: Each wave height is expected to occur on average once during the recurrence interval.

Source: *DOGAMI analyses; +Ruggiero et al. (2010).

Figure CE-11: Example map product showing erosion hazard zones developed for Rockaway Beach in Tillamook County. Note the erosion that has taken place since 1998 (red line) up through 2009 (black line)

Photo source: DOGAMI

Coastal Erosion Hazard Zones

For the purposes of providing erosion hazard information for the Oregon coast, DOGAMI has completed coastal erosion hazard maps for Lincoln, Tillamook and Clatsop Counties, as well in the Nesikka Beach area in Curry County. Maps were completed for these areas mainly because these areas contain the largest concentration of people living along the coastal strip, and in the case of Nesika Beach in response to a specific request by the Department of Land Conservation and Development agency. In all cases, the maps depict erosion hazard zones that fall into four categories (Figure CE-11):

1. Active Hazard Zone (AHZ): For dune-backed shorelines, the AHZ encompasses the active beach to the top of the first vegetated foredune, and includes those areas subject to large morphological changes adjacent to the mouths of the bays due to inlet *migration. On bluff-backed shorelines the AHZ includes actively eroding coastal bluff escarpments and active or potentially active coastal landslides.*

2. High Hazard Zones (HHZ): This scenario is based on a large storm wave event (wave heights ~47.6 ft high) occurring over the cycle of an above average high tide, coincident with a 3.3 ft storm surge. The wave heights associated with this scenario have an expected recurrence interval of 50-60 years or a 2% chance in any given year.

3. Moderate Hazard Zones (MHZ): This scenario is based on an extremely severe storm event (waves ~52.5 ft high) and may or may not encompass a long-term rise in sea level (depends on the coastal region). As with the HHZ, the wave event occurs over the cycle of an above average high tide, coincident with a 5.6 ft storm surge. The wave heights associated with this scenario have an expected recurrence interval of 100 years or a 1% chance in any given year.

4. Low Hazard Zones (LHZ): This scenario is analogous to the MHZ scenario described previously, with the addition of a 3.3 ft coseismic subsidence of the coast.

Drought

The state of Oregon is confronted with continuing challenges associated with drought and water scarcity. The challenges are "exacerbated" because of a rapidly growing population and the demands placed on a renewable, yet finite resource - water. The two terms, drought and water scarcity, are not necessarily synonymous; distinctly water scarcity implies that demand is exceeding the supply. The combined effects of drought and water scarcity are far-reaching and merit special consideration.

Drought is typically measured in terms of water availability in a defined geographical area. It is common to express drought with a numerical index that ranks severity. Most federal agencies use the Palmer Method which incorporates precipitation, runoff, evaporation, and soil moisture. However, the Palmer Method does not incorporate snowpack as a variable. Therefore, it is not believed to provide a very accurate indication of drought conditions in Oregon and the Pacific Northwest.

The Oregon Drought Severity Index is the most commonly used drought measurement in the state. It is considered to be a better indicator of drought severity because it incorporates both local conditions and mountain snowpack. The Oregon Drought Severity Index categorizes droughts as mild, moderate, severe, and extreme. The index is available from the Oregon Drought Council.

Figure 2-D-1: Methods of Measuring Droughts

Source: State of Oregon Emergency Operations Plan, Drought Annex 2002

Analysis/Characterization

Drought can be defined several ways. The American Heritage Dictionary defines drought as "a long period with no rain, especially during a planting season." While straight forward, this definition falls far short of the benchmark needed to assess the extent or severity of the hazard and how it might be mitigated.

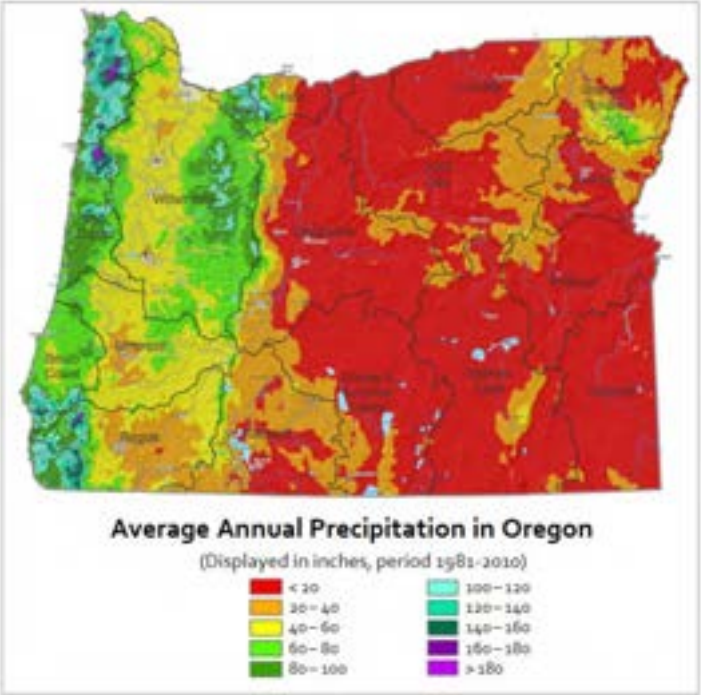

Figure 2-D-2: Oregon Average Annual Precipitation, 1981-2010

Source: PRISM Group, Oregon State University
Map: Oregon Water Resource Department
Website: http://www.prismoregonstate.edu and http://prism.oregonstate.edu/state_products/index.phtml

In the early 1980's, researchers with the National Drought Mitigation Center and the National Center for Atmospheric Research located more than 150 published definitions of drought. There clearly was a need to categorize the hazard by "type of drought." The following definitions are a response to that need:

Meteorological or climatological droughts usually are defined in terms of the departure from a normal precipitation pattern (Figure 2-D-1) and the duration of the event. Drought is a slow-onset phenomenon that usually takes at least three months to develop and may last for several seasons or years.

Agricultural droughts link the various characteristics of meteorological drought to agricultural impacts. The focus is on precipitation shortages and soil-water deficits. Agricultural drought is largely the result of a deficit of soil moisture. A plant's demand for water is dependent on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and the physical and biological properties of the soil.

Hydrological droughts refer to deficiencies in surface water and sub-surface water supplies. It is measured as stream flow, and as lake, reservoir, and ground water levels. Hydrological measurements are not the earliest indicators of drought. When precipitation is reduced or deficient over an extended period of time, the shortage will be reflected in declining surface and sub-surface water levels.

Socioeconomic droughts occur when physical water shortage begins to affect people, individually and collectively. Most socioeconomic definitions of drought associate it with supply, demand, and economic good. One could argue that a physical water shortage with no socio-economic impacts is a policy success.

History of Droughts in Oregon

Oregon records, dating back to the late 1800s, clearly associate drought with a departure from expected rainfall. Concern for mountain snowpack, which feeds the streams and rivers, came later. Some Oregon droughts were especially significant during the period of 1928-1994.[2] The period from 1928 to 1941 was a prolonged drought that caused major problems for agriculture. The only area spared was the northern coast, which received abundant rains in 1930-33. The three Tillamook burns (1933, 1939, and 1945) were the most significant results of this very dry period. During 1959-1962 stream flows were low throughout eastern Oregon, but areas west of the Cascades had few problems. Ironically, the driest period in western Oregon was the summer following the benchmark 1964 flood. Low streamflows prevailed in western Oregon during the period from 1976-81, but the worst year, by far, was 1976-77, the single driest year of the century. The Portland Airport received only 7.19 inches of precipitation between October 1976 and February 1977, only 31 percent of the average 23.16 inches for that period.

The 1985-94 drought was not as severe as the 1976-77 drought in any single year, but the cumulative effect of ten consecutive years with mostly dry conditions caused statewide problems. The peak year of the drought was 1992, when a drought emergency was declared for all Oregon counties. Forests throughout the state suffered from a lack of moisture. Fires were common and insect pests, which attacked the trees, flourished.

In 2001 and 2002, Oregon experienced drought conditions, affecting 6 out of 8 regions. During the 2005 drought, the Governor issued declarations for thirteen counties, all east of the Cascades, and the USDA issued three drought declarations, overlapping two of the Governor's. State declarations were made for Baker, Wallowa, Wheeler, Crook, Deschutes, Klamath, Lake, Hood River, Wasco, Sherman, Gilliam, Morrow, and Umatilla counties. Federal declarations were made in Coos, Klamath, and Umatilla counties. Federal drought declarations by the USDA provide accessibility to emergency loans for crop losses. Since 2001, the Governor has declared a drought every year, with the exception of 2006, 2009, and 2011, in at least one Oregon county. Most of these declarations have involved one or more counties in Regions 5-8.

Impacts

Droughts are not just a summer-time phenomenon; winter droughts can have a profound impact on the state's agricultural sector, particularly east of the Cascade Mountains. Also, below average snowfall in Oregon's higher elevations has a far-reaching effect on the entire state, especially in terms of hydroelectric power generation, irrigation, recreation, and industrial uses. In March of 2014, Mt. Ashland Ski Resort in Southern Oregon announced that it would be unable to open due to the lack of snow[7]. The lack of snow has affected other regions of the state. In the Klamath Basin, the Natural Resources Conservation Service reports that the mountains are generally snow-free below 5000 feet. The Taylor Butte SNOTEL site at elevation 5030 feet was snow-free on March 1, 2014 for the first time since it was installed in 1979. Five long-term snow measurement sites in the Klamath basin set new record lows for March 1 snowpack. The lack of snow and precipitation during the winter months led Governor Kitzhaber to declare a drought for 4 Oregon counties – Klamath, Lake, Harney, and Malheur – in February 2014. As of March 18, 2014, the U.S. Drought Monitor reports that nearly half of Oregon is experiencing a severe drought (Figure 2-D-3).

[7] http://www.oregonlive.com/travel/index.ssf/2014/03/mount_ashland_gearing_up_to_ce.html

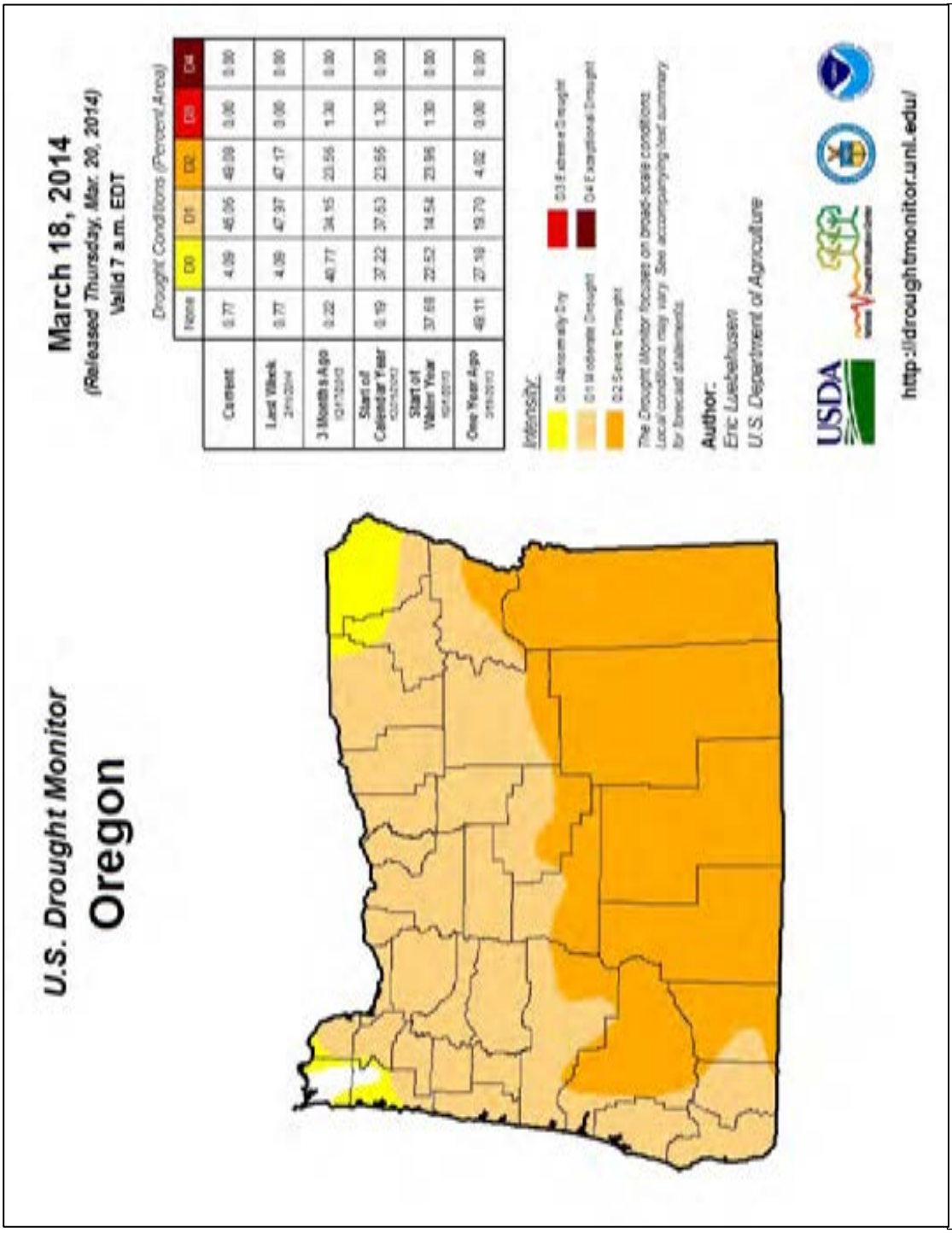

Figure 2-D-3: March 18, 2014 U.S. Drought Monitor Report for Oregon.

Source: U.S. Drought Monitor

There also are environmental consequences. A prolonged drought in Oregon's forests promotes an increase of insect pests, which in turn, damage trees already weakened by a lack of water. In the Willamette Valley, for example, there has been an unusual pattern of tree mortality involving Douglas-fir, grand fir, and western red cedar. Water stress brought on by drought and other factors is the central cause in these mortality events.

A moisture-deficient forest constitutes a significant fire hazard (see the Wildfire section of this Plan, pg. xx). In addition, drought and water scarcity add another dimension of stress to imperiled species. The following information addresses the impact of a severe or prolonged drought on the population, infrastructure, facilities, the economy, and environment of Oregon:

Population: Drought can affect all segments of Oregon's population, particularly those employed in water-dependent activities (e.g., agriculture, hydroelectric generation, recreation, etc.). Also, domestic water-users may be subject to stringent conservation measures (e.g., rationing) and could be faced with significant increases in electricity rates.

Infrastructure: Infrastructure such as highways, bridges, energy conveyance systems, etc., are typically unaffected by drought; however drought can cause structural damage. [5] An example would include areas of severe soil shrinkage. In these uncommon situations, soil shrinkage would affect the foundation upon which the infrastructure was built. In addition, water-borne transportation systems (e.g., ferries, barges, etc.) could be impacted by periods of low water.

Critical/Essential Facilities: Facilities affected by drought conditions include communications facilities, hospitals, and correctional facilities that are subject to power failures. Storage systems for potable water, sewage treatment facilities, water storage for firefighting, and hydroelectric generating plants also are vulnerable. Low water also means reduced hydroelectric production especially as the habitat benefits of water compete with other beneficial uses.

State Owned or Operated Facilities: There are a variety of state owned or operated facilities that could be affected by a prolonged drought. The most obvious include schools, universities, office buildings, health-care facilities, etc. Power outages always are a concern. Maintenance activities (e.g., grounds, parks, etc.) may be curtailed during periods of drought.

Economy: Drought has an impact on a variety of economic sectors. These include water-dependent activities and economic activities requiring significant amounts of hydroelectric power. The agricultural sector is especially vulnerable as are some recreation-based economies (e.g., boating, fishing, water or snow skiing). Whole communities can be affected. This was particularly evident during 2001 water year when many Oregon counties sought relief through state and federal drought assistance programs.

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[5] Some clay soils (e.g., containing bentonite) have significant shrink-swell properties. Prolonged drought can shrink these soils resulting in structural damage. Although these soils occur in Oregon, their geographical extent is limited.

The years 2000 and 2001 were the second driest years in Oregon's climate history. Marion County's recreation community of Detroit suffered economic hardships when adjacent reservoir levels became too low to support normal summer activities. In addition, the drought directly affected over 200,000 irrigated acres in the Klamath River Basin. Farmers were among the first to be affected, followed by local agricultural support industries (e.g., pesticides, fertilizer, farm equipment, etc.), as well as Native American Tribes which depend on local fisheries. There were also endangered species considerations.

Environment: Oregon has several fish species listed as threatened or endangered under the Endangered Species Act (ESA). Some of these species have habitat requirements that jeopardized by the needs or desires of the human environment. For example, in times of scarcity, the amount of water necessary to maintain certain fish species may conflict with the needs of consumptives uses of water. . The state of Oregon is committed to implementation of the ESA and the viability of a productive economic base. There are no easy solutions, only continuous work to resolve difficult drought situations.

Historic Droughts in Oregon

Historic drought events in Oregon are listed in Table 2-DR-1.

Table 2-DR-1: Historic Droughts in Oregon

Date	Location	Description
1904-05	Statewide	18 month drought.
1917-31	Statewide	Dry period punctuated by brief wet spells (1920, 1927).
1939-41	Statewide	Three-year intense drought.
1965-68	Statewide	Three-year drought following big regional floods of 1964-65.
1976-77	Statewide	Brief, but very intense drought. Regional impacts, affecting much of the U.S., especially the west and the Great Plains.
1985-94	Statewide	Generally dry period, capped by statewide droughts in 1992 and 1994.
2001-02	Affected all Regions, except Regions 2 & 3	The second most intense drought in Oregon's history. Eighteen counties with state drought declaration (2001).Twenty-three counties state-declared drought (2002). Some of the 2001 and 2002 drought declarations were in effect through June or December 2003.
2003	Regions 5, 6, 7, & 8	Governor-declared drought issued in 7 counties: Sherman, Wheeler, Crook, Baker, Wallowa, Malheur, & Harney
2004	Regions 5, 6, 7, & 8	Governor-declared drought issued in 4 counties: Morrow, Klamath, Baker, and Malheur
2005	Regions 5, 6, and 7	Affected area: thirteen of Oregon's thirty-six counties.
2007	Regions 6, 7, and 8	Governor-declared drought emergency in Lake, Grant, Baker, Union, Malheur, and Harney counties
2008	Region 5	Governor-declared drought emergency in Sherman and Gilliam counties
2010	Region 6	Governor-declared drought emergency for Klamath County and contiguous counties
2012	Region 6	Governor-declared drought emergency for the Lost River Basin, located in Klamath County and Lake County

2013	Regions 5, 6, 7, & 8	Governor-declared drought in Gilliam, Morrow, Klamath, Baker, and Malheur counties
2014	Regions 6 & 8	Governor-declared drought in Klamath, Lake, Malheur, and Harney counties. Oregon experienced its third driest November – January period since 1895.

Source:Taylor, George and Raymond R Hatton. (September 1999). The Oregon Weather Book: State of Extremes. Governor-declared drought declarations obtained from the Oregon State Archives division.

Probability

Drought is a normal, recurrent feature of climate, although many erroneously consider it a rare and random event. It is a temporary condition and differs from aridity because the latter is restricted to low rainfall regions and is a permanent feature of climate. It is rare for drought not to occur somewhere in North America each year. Despite impressive achievements in the science of climatology, estimating drought probability and frequency continues to be difficult. This is because of the many variables that contribute to weather behavior, climate change, and the absence of historic information. Nevertheless, progress is being made, particularly in the area of cyclic climatic variations.

Cyclical Climatic Variations

There is a great deal of debate about cyclic climatic changes in Oregon and the Pacific Northwest. The dialogue seems to center on two Pacific weather systems, El Niño and La Niña, but there also is considerable interest in two much larger systems: the El Niño Southern Oscillation (ENSO) and its counterpart, the Pacific Decadal Oscillation (PDO). Simply stated, all of these systems involve the movement of abnormally warm or cool water into the eastern Pacific, dramatically affecting the weather in the Pacific Northwest.

An El Niño system moves heat, both in terms of water temperature and in atmospheric convection. The heat is transported toward North America, producing mild temperatures and dry conditions in Oregon. Its effects are most pronounced from December through March. It appears to occur in cycles of two to seven years and its effects have become fairly predictable.

La Niña conditions are more or less opposite those created by El Niño. It involves the movement of abnormally cool water into the eastern Pacific. This event produces cooler than normal temperatures in Oregon and increased precipitation. It also is most pronounced from December to March. Typically, El Niño events occur more frequently than La Niña events.

- Drought is often associated with water scarcity, which usually is perceived as a "human-caused" hazard, rather than a "natural" hazard.
- Drought is frequently an "incremental" hazard, the onset and end are often difficult to determine. Also, its effects may accumulate slowly over a considerable period of time and may linger for years after the termination of the event.
- Quantifying impacts and provisions for disaster relief is a less clear task than it is for other natural hazards.
- The lack of a precise and universally accepted definition adds to the confusion about whether or not a drought actually exists.
- Droughts are often defined by growing seasons, the water year, and livestock impacts.

Figure D-4: drought – the nebulous natural hazard

Predicting Droughts in Oregon

Predicting weather patterns is difficult at best, however the 1997-98 El Niño event marked the first time in history that climate scientists were able to predict abnormal flooding and droughts months in advance for various locations around the United States.3 The methodology consists of monitoring water temperatures, air temperatures, and relative humidity plus measuring sea-surface elevations. Once an El Niño or La Niña pattern is established, climatologists can project regional climatic behavior. Although the scientific community is enthusiastic about its recent successes, all droughts are not associated with El Niño / La Niña events.

[3] nationalgeographic.com, 1999

Dust Storms

A dust storm is a strong, violent wind that carries fine particles such as silt, sand, clay, and other materials, often for long distances. The fine particles swirl around in the air during the storm. A dust storm can spread over hundreds of miles and rise over 10,000 feet. They have wind speeds of at least 25 miles per hour.

> Think dusts storms aren't a serious natural hazard? Over the past 40 years in Oregon, more than ten people have been killed and more than 60 injured – some very seriously – due to automobile accidents caused by dust storms, often exacerbated by excessive speed.

Dust storms usually arrive with little warning and advance in the form of a big wall of dust and debris. The dust is blinding, making driving safely a challenge. A dust storm may last only a few minutes at any given location, but often leave serious car accidents in their wake, occasionally massive pileups.

Dust storms occur most frequently over deserts and regions of dry soil, where particles are loosely bound to the surface. Dust storms don't just happen in the middle of the desert, however. They happen in any dry area where loose dirt can easily be picked up by wind. Grains of sand, lofted into the air by the wind, fall back to the ground within a few hours, but smaller particles remain suspended in the air for a week or more and can be swept thousands of kilometers downwind. Dust from the Sahara desert regularly crosses the Atlantic, causing bright red sunrises and sunsets in Florida, traveling as far as the Caribbean and the Amazon Basin.[8]

Airborne dust particles, or dust aerosols, alter the climate by intercepting sunlight intended for the surface. By shading the earth from the sun's radiation, dust aerosols have the same effect as a rain cloud. While solar radiation is reduced beneath the dust cloud, the absorption of sunlight by dust particles heats the cloud itself.

Approximately half of the dust in today's atmosphere may result from changes to the environment caused by human activity, including agriculture, overgrazing, and the cutting of forests. Data from dust traps near urban areas like Las Vegas show that the spread of housing and other human construction across the desert directly causes increases in dust storms by destabilizing the surface and vegetation.

Analysis and Characterization

Intensive tillage of soils in agricultural uses is also a significant condition releasing soil to make it easily transportable by high winds. Depending on the crop and region involved, tillage may be occurring in the spring and/or in the autumn. Research in north-central Oregon and south-central Washington indicates that region's dust problem isn't simply a matter of soil being redistributed from one field to another by the wind. Fine particulate becomes suspended in the air and may travel thousands of miles. Scientists indicate that the region is truly losing soil.

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[8] Some of the preceding material is from http://www.kidzworld.com/site/p707.htm#

"In September of 1999, after a long dry summer, a farmer was plowing his wheat fields in Eastern Oregon on a blue-sky day. A freak wind whipped up and dust covered the roadway. Instantly, everything went black. Later, they found dead people in cars with the cruise controls still set as high as 75 miles an hour. One person involved in the accident tried to go back to warn others. He waved at them, but the passing drivers just waved back... The last sight the young man had of one trucker was the trucker driving full bore into the dust storm, both hands off the wheel as he waved at the young man."
(April Henry from *Learning to Fly*)

During this September 25, 1999 dust storm, high winds blowing dust set off a chain-reaction of crashes that killed eight people and injured more than twenty. In all, more than forty vehicles crashed in separate pileups in both freeway directions between Hermiston and Pendleton. Parts of Interstate 84 were blocked from mid-morning until nearly midnight.

Huge dust clouds set off by 50 mile per hour winds, dry soil, recent planting of nearby wheat fields and harvesting of potato fields created extremely hazardous driving conditions that fateful morning. However, an Oregon State Police (OSP) report on the dust storm didn't blame the weather. It reported that driving too fast for conditions was the primary cause of the pileups.

The report indicated that neither OSP nor ODOT had enough warning time to close the freeway before the chain reaction crashes started. Five minutes after OSP noticed that visibility on the freeway was rapidly getting worse, the accidents started.

Community Solutions Team meetings held in early 2000 determined that focusing on the Natural Resources Conservation Service, and Soil and Water Conservation District practices shown on pages xx will help reduce the volume of materials available to be whipped-up in dust storms.

These meetings also resulted in initiatives to increase detection and warning time. These allow OSP and ODOT to temporarily close certain highways, as well as better inform and advise the traveling public.

Several other ideas were examined for possible implementation along the I-84 corridor. Most were determined to be either ineffective or impractical for solving the problems of dust storms that occasionally occur in the area.

Derived from the reports developed by a Community Solutions Team and Oregon State Police after the September 25, 1999 Umatilla County dust storm

Air quality is adversely affected by windblown dust. Oregon's Department of Environmental Quality (DEQ) has developed a rule concerning air pollution caused by particulates from volcanic ashfall or windblown dust. Excerpts from that rule are shown in Appendix XX.

> "We called the weather service about 9:30 saying that visibility was getting bad… I could see the dust coming in a big cloud from the southwest. There's too much tillage to the west and southwest of us. You get a wind event like we had and that soil is loose, powdery and lifting, and I don't think you can stop it… Farming by its very nature, particularly in this country on these soils, at some time is going to involve tillage, and when it does… you're going to have exposure to winds… have wind and exposed soil, you're going to have dust."

Pendleton area farmer and member of the Oregon Wheat Growers League, talking about the September 25, 1999 event

Although many people are aware of the negative effects of dust storms such as vehicle crashes on highways, erosion of topsoil, dust in electronic equipment and aircraft engines, and poor air quality, a less obvious but important effect of dust storms and volcanic ashfall is not widely known: dust and ash deposited on the ground surface in new locations is eventually carried down into the soil by rain, providing important nutrients for plants in those locations.

> "(Farmers) say this is a problem the Columbia Basin, composed of mostly sandy soils, has experienced every spring before the rapid farm development that has followed circle irrigation… Luther Fitch, county extension agent in Hermiston… facetiously said Wednesday's winds 'probably sent a foot of topsoil back to Montana… undoubtedly there will be considerable need to replant spring wheat and potatoes. Fertilizer will have moved on and needs to be reapplied.' " *East Oregonian*, Steve Clark, Friday, March 26, 1976, p.1

> "…dust from freshly plowed fields hung heavy over much of Oregon last night as a windstorm of gale proportions continued unabated. One death and several injuries were attributed to the storm… Political storms abated for the moment, Salem lay yesterday under a pall of Eastern Oregon dust, which the oldest old-timers said was unique in the city's history. A swirling northeast wind drove tons of Eastern Oregon dust before it, down the Columbia Gorge and into Western Oregon. Diverting down the Willamette River at Portland, the dust clouds reached the valley early Wednesday morning and shrouded the entire country… Lights went on in schools, homes, and business houses as though the day was mid-winter… Old-timers in Salem scratched their heads yesterday and tried to recall a parallel in storm history for the dust invasion… but no precedent for the gale of dirt could be recalled. 'I recall a terrific storm in January 1880,' said A.N. Moores. 'However, it was a wind storm alone and there was no dirt accompanying it'… (Mill City) was surprised Tuesday evening when a heavy bank of clouds filled with dust began to work its way over the mountains and shut off the view of the surrounding hills by its denseness."
>
> *Oregon Statesman*, Thursday, April 23, 1931, pp.1-2

During June 2004, a group of residents of Summer Lake, known as Friends of Summer Lake, asked the state to divert to the lake a third of the water that currently feeds a wildlife sanctuary and irrigates pastures, contending that these uses make the lake dry-up sooner and more often. Another factor in the lake drying-up, however, is increased development in and around the basin, which has reduced the underground aquifer, decreasing the flow of springs.

Rainfall in the area, mostly during winter, averages 12 inches per year, but evaporation in the high desert - where summer temperatures can climb to 105 degrees - averages 40 to 50 inches per year.

Darrell Seven, who owns Summer Lake Inn with his wife, Jean Sage, said wind whipping over the dry lakebed causes alkali dust storms. "It's hard to breathe, it's irritating and it makes you sick," said Seven, who has been in the valley for 30 years. "I lose customers all the time who say they just can't handle it."

Alan Withers, president of the Summer Lake Irrigation District said, however, "This lake isn't very pretty, and we get a lot of dust down here. It's nature's way."

Based on an Associated Press article

Competition for scarce water can affect the location and frequency of dust storms.

Historic Dust Storms in Oregon

Table 2-DU-1 lists historic dust storms in Oregon.

Table 2-DU-1: Historic Dust Storms in Oregon

Date	Location	Description
May 1843[9]	Columbia Gorge, OR	Rev. Gustavus Hines, who was traveling by canoe with a Dr. Davis in the Columbia Gorge, reported this storm
1906	Mid-Willamette Valley, OR	News reports from the April 1931 event (see below) make historical reference to "the great sandstorm of 1906 that lasted two weeks."
April 1931[10]	Columbia Gorge, Central Oregon, north and mid-Willamette Valley, and Santiam Canyon, OR	A swirling northeast wind drove tons of dust down the Columbia Gorge and into Portland and the north and mid-Willamette Valley; a heavy bank of clouds filled with dust also reportedly worked their way over mountain passes into the Santiam Canyon.
May 1975[11]	Near Echo Junction, OR	Winds up to 45 mph blew dust from nearby plowed fields, resulting in a seven-car accident on a Friday afternoon in the eastbound lanes of Interstate 80 (now I-84); four injured.
March 1976[12]	Near Stanfield, OR	Eighteen vehicles piled-up in two separate accidents on Interstate 80, now I-84; these accidents killed one and

[9] Diary of Rev. Gustavus Hines

[10] *Oregon Statesman*, "Dust, Wind, and Fire Cause Great Damage," April 23, 1931 and "Dust Storm Precedent on Record 88 Years Ago," April 26, 1931; information on this event, as well as the 1906 event, may also be found in the *Pacific Northwest Quarterly*, "The Pacific Northwest Dust Storm of 1931," Paul C. Pitzer, April 1988, pp. 50-55, as informed by the following sources used by Mr. Pitzer:

Albany *Democrat-Herald*, April 22, 1931
Astoria *Evening Budget*, April 24, 1931
Coos Bay *Times*, April 22, 23, 1931
Corvallis *Gazette-Times*, April 22, 24, 1931
Pendleton *East Oregonian*, April 22, 1931
Portland *Oregonian*, April 22, 25, 26 and May 1, 1931
Portland *Oregonian*, Lancaster Pollard, August 21, 1955 and November 25, 1962
Roseburg *News-Review*, April 22, 23, 1931
Salem *Oregon Journal*, April 22, 23, 24, 1931
San Francisco *Chronicle*, April 25, 1931
The Dalles *Optimist*, April 24, 1931
Wenatchee *Daily World*, April 22, 1931
Beef Cattle Industry in Oregon: 1890-1938, Dexter K. Strong, 1940
Wind Erosion and Dust Storms in Oregon, Arthur King, 1938.

[11] *East Oregonian*, May 24, 1975

[12] *East Oregonian*, March 24, 25, and 26, 1976, including articles titled "18 Vehicles Crash in Dust Storm; Woman Killed" and "Dust Problem Stymies Farmers"; *Oregon Statesman*, "Dust Storms Hit E. Oregon…", March 25, 1976

		injured 20 people; they were caused by a dust storm (referred to in the press as a sand storm) that produced "near zero" visibility; one of the pile-ups was a fiery accident involving a loaded fuel tanker truck, two other trucks, and two cars; this dust storm also caused road closures both south and north of Hermiston, and caused other accidents on Highway 207 about nine miles south of I-80 (84).
July 1979[13]	Near Stanfield	This dust storm caused two deaths and six injuries in a freeway pile-up on I-80 (84) very close to the location of the previous event; winds near 60 mph; some of the injured were hit as pedestrians while trying to assist those already injured or pinned in automobiles.
Sept. 1999[14]	Morrow and Umatilla Counties	Blowing dust off wheat fields killed eight and injured more than twenty people in chain-reaction auto crashes.
April 2001[15]	Near Klamath Falls	Highway 97 about five miles north of Klamath Falls was closed for approximately six hours following three separate crashes; eleven cars were involved, sending nine people to the hospital; the accidents were due to severely limited visibility caused by high winds blowing dust from a recently plowed field across the highway.
June 2004[16]	Lake County	Blowing dust from a dry lake bed filled the sky in and near Summer Lake.
March 2005[17]	Near Boardman, and in Deschutes County	Weather stations at nineteen locations measured peak wind gusts from 45 to 64 mph. Visibility restrictions down to near zero due to blowing dust occurred along I-84 between Boardman and Pendleton. Extremely low visibilities led to road closures and multiple vehicle pileups. Vehicles pulled off the road to avoid collisions. Visibilities of a half mile or less due to flowing dust were also reported in Deschutes County.
Jan. 2008[18]	Baker, Morrow, Umatilla,	ODOT closed the freeway's westbound lanes between

[13] *Oregon Statesman*, "2 Dead, 6 Injured in Freeway Accident; Dust Storm Blamed," July 11, 1979

[14] *La Grande Observer*, "State Gives Dust Storm Driving Advice," October 1, 1999 and "Report Blames Speed," November 20, 1999; *Statesman Journal*, "Six Die in 50-car Pileup on I-84: Dust Blinds Drivers on the Interstate near Pendleton," September 26, 1999, "Dust Brownout Led to Fatal Wrecks: Dry Weather and High Winds Created the Deadly Eastern Oregon Storm," September 27, 1999, and "Road Warnings Needed: Motorists Can Learn from Last Week's Fatal Dust Storm Collisions," October 5, 1999; *Corvallis Gazette-Times*, "Corvallis Couple Recovering from Highway Crash," September 27, 1999; *Learning to Fly*, April Henry; *East Oregonian,* Mitchell Zach; Associated Press news story dated September 26, 1999; also post-event documents of the Community Solutions Team (meeting minutes) and Oregon State Police

[15] Weather Channel website, April 18, 2001

[16] Associated Press, TBD

[17] TBD

	and Union Counties, OR	Baker City and La Grande about noon because of blowing snow, dust, and debris that created near-zero visibility in the Ladd Canyon area east of La Grande. The eastbound freeway lanes were closed between mile point 193 west of Pendleton and Baker City because of high winds, crashes, and visibility issues. Five patrol cars and two pickup trucks operated by troopers responding to overturned vehicles received windshield and body damage from wind-blown rocks. ODOT also closed Oregon 11 between Pendleton and Milton-Freewater. Police reported several accidents caused by low visibility, blowing dust and debris.
Nov. 2009[19]	Lake County, OR	An alkaline dust storm blew into Lakeview.
Aug. 2012[20]	Harney and Malheur Counties, OR	A massive dust storm due to 50 to 60 mph winds produced by thunderstorms eventually blew on into Idaho; some media reports indicate this event darkened the skies in some areas for more than two hours.
March 2013[21]	Malheur County, OR	Dust from this storm is reported to have accelerated snowmelt in a Southwestern Idaho mountain range. ‘ nobody on our staff has ever witnessed anything similar, : said Adam Winstral, Research Hydrologist with the U.S. Depertment of Agriculture.
Sept. 2013[22]	Baker and Umatilla Counties, OR	Dust storm occurs in and near Baker City; dust storms two weeks apart hit Weston.

Sources: Various sources, See footnotes

[18] TBD

[19] http://en.wikipedia.org/wiki/Goose_Lake_(Oregon-California)

[20] *Idaho Press Tribune* (Tom Dale), August 6, 2012; KTVB, August 5, 2012; KBOI, August 5, 2012; USGS, *Dust, an emerging problem in the Great Basin: insights from 2012,* January 23, 2013; YouTube, Brenda Burns, published August 6, 2012 and Zeronieo, published August 14, 2012; *Mother Recounts Her Encounter with an Oregon Dust Storm,* Yahoo Voices, August 8, 2012

[21] *The Oregonian* (oregonlive,com), March 29, 2013; *Idaho Statesman* (Rocky Barker), March 28, 2013

[22] *Daily Mail*, September 16, 2013; YouTube, Fredrik Anderson, September 12, 2013

Probability

Based on a literature search conducted by the Oregon Office of Emergency Management (OEM), thirteen significant dust storms have been recorded in Oregon over the past 40 years. Four of these were during 2012 and 2013, which suggests a bias in the research toward more recent events. Based strictly on the average, the recurrence interval is about once every three years for significant dust storms. However, the mid '70s, the millennium roll-over years, and other short time periods seem to have produced more storms. There may be a relationship with ENSO, droughts, or some other weather pattern. This would benefit by more research.

Earthquake

Oregon has experienced few damaging earthquakes during its recorded history, leading to complacency and lack of attention to earthquake-resistant design and construction. Since the mid-1980's, an increasing body of geologic and seismologic research has changed the scientific understanding of earthquake hazards in Oregon, and in recent years several large and destructive earthquakes around the world have heightened public awareness. Recognized hazards range from moderate sized crustal earthquakes in eastern Oregon to massive subduction zone megathrust events off the Oregon coast. All have the potential for significant damage as long as most of Oregon's buildings and infrastructure have inadequate seismic resistance. The scale of structural retrofit and replacement needed to make Oregon earthquake safe is huge, and beyond our capacity to implement in anything less than decades. To manage the human and economic impact of the next damaging earthquake will require thoughtful and comprehensive emergency response planning, based on realistic loss estimates driven by accurate and detailed geologic and seismologic, structural and cultural information. To minimize the human and economic impact of the next damaging earthquake will require a sustained program of public education, forward-thinking research, and structural replacement and retrofit, based on cost-effective earthquake resistant design and a combination of public funding and private sector incentives.

Analysis and Characterization

Earthquake sources

Earthquakes are a highly variable natural phenomenon. The vast majority occur when two masses of rock in the earth's crust abruptly move past each other along a large crack or fracture called a fault. The energy released as the two parts slide along the fault produces waves of shaking that we perceive as an earthquake. Faults typically build up stress over decades to millennia in response to large scale movement of the earth's tectonic plates. Even the most active faults only produce damaging earthquakes at intervals of a century or more, and for many the intervals are much longer. As a result, it is very difficult to forecast the likelihood of an earthquake on a particular fault because we rarely have a long enough record to determine a statistically meaningful return period (average time between earthquakes).

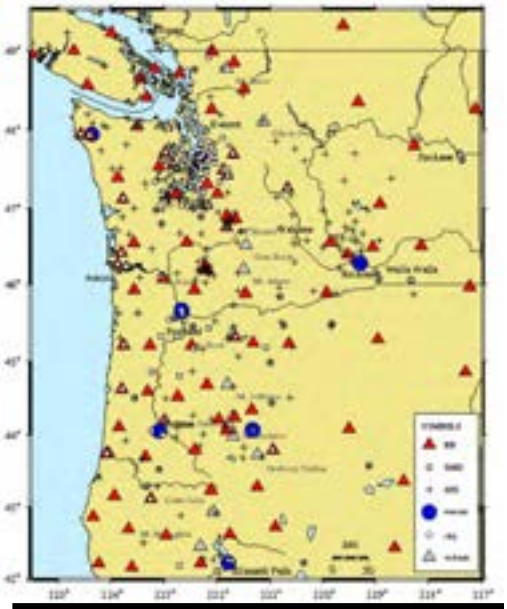


Figure 2-EQ-1: Current configuration of the network of earthquake monitoring stations in the Pacific Northwest, The system is operated out of the University of Washington by the Pacific Northwest Seismic Network.

Source: Pacific Northwest Seismic Network at website: http://www.pnsn.org/

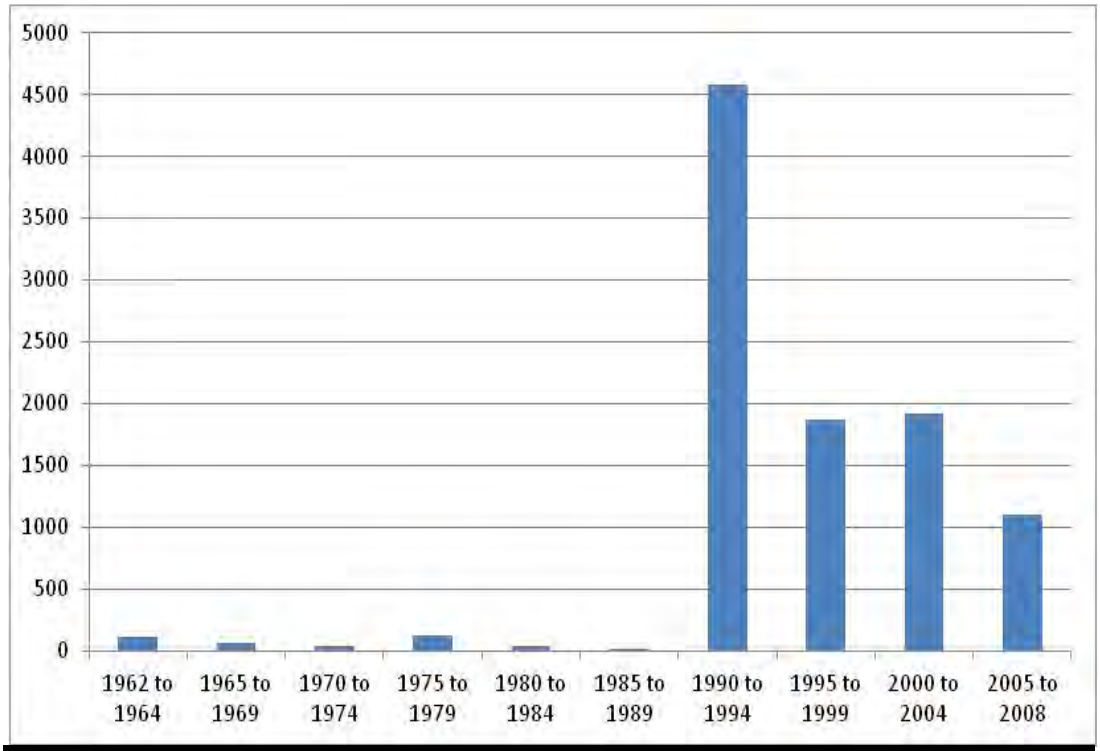


Figure 2-EQ-2: Annual rate of earthquake occurrence in Oregon, in 5-year increments. Seismic instruments began operation in 1970, but the network only became fully effective in 1990. Huge spikes in earthquake numbers in the early 1990s are aftershocks from the 1993 Scotts Mills and Klamath Falls earthquakes.

The history of earthquakes in a region comes from three types of information. Instrumental data comes from networks of seismic recording instruments (seismographs) that are widely deployed in the Pacific Northwest.

Seismic networks can detect very small earthquakes, locate them to within a few miles, and determine their magnitude accurately. Seismographs have only existed for about a century, and in Oregon, the instrumental record is really only complete and modern from about 1990 on. Historical felt location data comes from verbal and written reports of earthquake effects. The felt record extends back to the mid 1800's for Oregon, but only locates moderate to large earthquakes, and those only with an accuracy of tens or even hundreds of miles.

Paleoseismic data uses geologic records of earthquake effects to determine the approximate size and timing of earthquakes that happened in prehistoric times. The paleoseismic record can extend back for thousands or tens of thousands of years, but provides only approximate information about the size, time and place of past large earthquakes.

In Oregon, the combined earthquake history derived from these three sources clearly outlines two major types of earthquake hazard and two less significant sources. By far the greatest is the hazard posed by infrequent **megathrust earthquakes** on the Cascadia Subduction Zone. The second major hazard comes from smaller **crustal earthquakes** on faults in or near populated areas, which includes all of Oregon's damaging historic earthquakes. Intraplate eathquakes, which have been historically damaging in the Puget Sound area are possible in Oregon but no damaging prehistoric or historic events are known. Finally, earthquakes associated with Oregon's many young volcanoes may produce damaging shaking in communities close to the volcano.

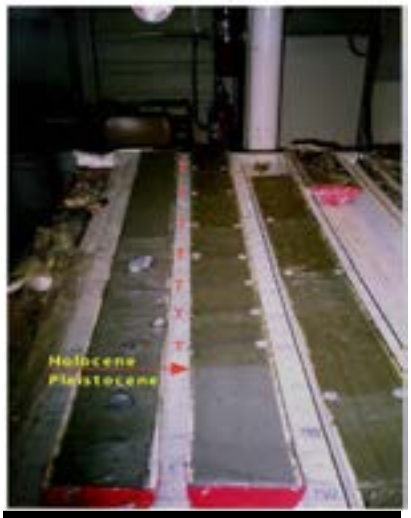


Figure 2-EQ-3: Deep sea sediment cores showing submarine landslide layers (turbidites) that record past megathrust earthquakes off the Oregon coast. Red T's mark the top of each layer.

Source: Goldfinger and others, 2011.

The Cascadia Subduction Zone is the boundary between two of the earth's crustal plates. These continent-sized plates are in constant slow motion, and the boundaries between plates are the site of most earthquake activity around the globe. At the Cascadia Subduction Zone, the Juan De Fuca plate, located offshore of Oregon and Washington, slides to the northeast and under the North American plate, which extends from the Oregon coast clear to the middle of the Atlantic Ocean. The Juan de Fuca plate slides beneath the continent (subducts) at about 1.5 inches per year, a speed which has been directly measured using high accuracy GPS. The fault that separates the plates extends from Cape Mendocino in Northern California to Vancouver Island in British Columbia, and slopes down to the east from the sea floor. The fault is usually locked, so that rather than sliding slowly and continuously, the 1.5 inches per year of subduction motion builds tremendous stress along the fault. This stress is periodically released in a megathrust earthquake, which can have a magnitude anywhere from 8.3 to 9.3.

Figure 2- EQ-4: Schematic 3-D map showing the general source areas for subduction zone, crustal earthquakes and intraplate earthquakes

Source: DOGAMI

Figure 2-EQ-4 (left) is a schematic three dimensional diagram with the generalized locations of the three types of earthquake sources found in Oregon: subduction zone, crustal and intraplate earthquakes.

The Cascadia Subduction Zone closely mirrors the subduction zone in northern Japan that produced the 2011 Tohoku earthquake (Figure EQ-5) . This magnitude 9 megathrust event and its associated tsunami captured the world's attention with unforgettable images of destruction on a massive scale. Oregon should regard this as a window into our future, as this is the very type of earthquake that our best science tells us is likely on the Cascadia Subduction Zone. Particular attention must be paid to the incredibly destructive tsunami that accompanied the Tohoku earthquake, and we must plan for a similar tsunami in Oregon (see the Tsunami section of this Plan, beginning on page 99, for more information about tsunamis in Oregon).

Figure EQ-5: Comparison of the subduction zone in northern Japan that was the setting for the 2011 Tohoku M 9.0 earthquake and the Cascadia subduction zone. Yellow patches are the measured earthquake rupture zone in Japan, modeled earthquake rupture zone in Oregon.

Source: DOGAMI

- ~16,000 dead
- ~4,000 missing (as of 10/12/2011)
- ~6,000 injuries
- ~300,000 homes destroyed
- ~600,000 homes damaged
- 92% of deaths due to tsunami (drowning)
- Fatality rate within the tsunami inundation zone ~16%
- Population within 40 km of coastline ~3,000,000

Figure 2-EQ-6: 2011 Tohoku earthquake numbers

Crustal earthquakes occur for the most part on shore on much smaller faults located in the North American plate,. These are the more familiar "California-style" earthquakes with magnitudes in the 5 to 7 range. Although much smaller than the megathrust earthquakes, crustal earthquakes may occur much closer to population centers, and are capable of producing severe shaking and damage in localized areas. For many parts of eastern Oregon, crustal faults dominate the hazard, and they may also have a significant impact in the Portland region and Willamette Valley.

Intraplate earthquakes are a third type that is common in the Puget Sound, where they represent most of the historical record of damaging events. In Oregon, these earthquakes occur at much lower rates, and none have ever been close to a damaging magnitude. They contribute little to the aggregate hazard in most of Oregon.

Earthquake Effects

Earthquake damage is largely controlled by the strength of shaking at a given site. The strength of shaking at any point is a complex function of many factors, but magnitude of the earthquake (which defines the amount of energy released) and distance from the epicenter or fault rupture, are the most important. The ripples in a pond that form around a dropped pebble spread out and get smaller as they move away from the source. Earthquake shaking behaves in the same way, and you can experience the same strength of shaking 10 miles from a magnitude 6 earthquake as you would feel 100 miles from a magnitude 9 earthquake.

Two measurement scales are used to describe the magnitude and intensity of earthquakes. To measure the magnitude the "Moment Magnitude" (M_w) scale uses the Arabic numbering scale. It provides clues to the physical size of an earthquake (NOAA-OAR-CPO-2014-2003692) and is more accurate than the previously used Richter scale for larger earthquakes. The second scale, the "Modified Mercalli," measures the shaking intensity and is based on felt observations and is therefore more subjective than the mathematically derived Moment Magnitude. It uses Roman numerals to indicate the severity of shaking. It is important to understand the relationship between the intensity of shaking the amount of damage expected from a given earthquake scenario.

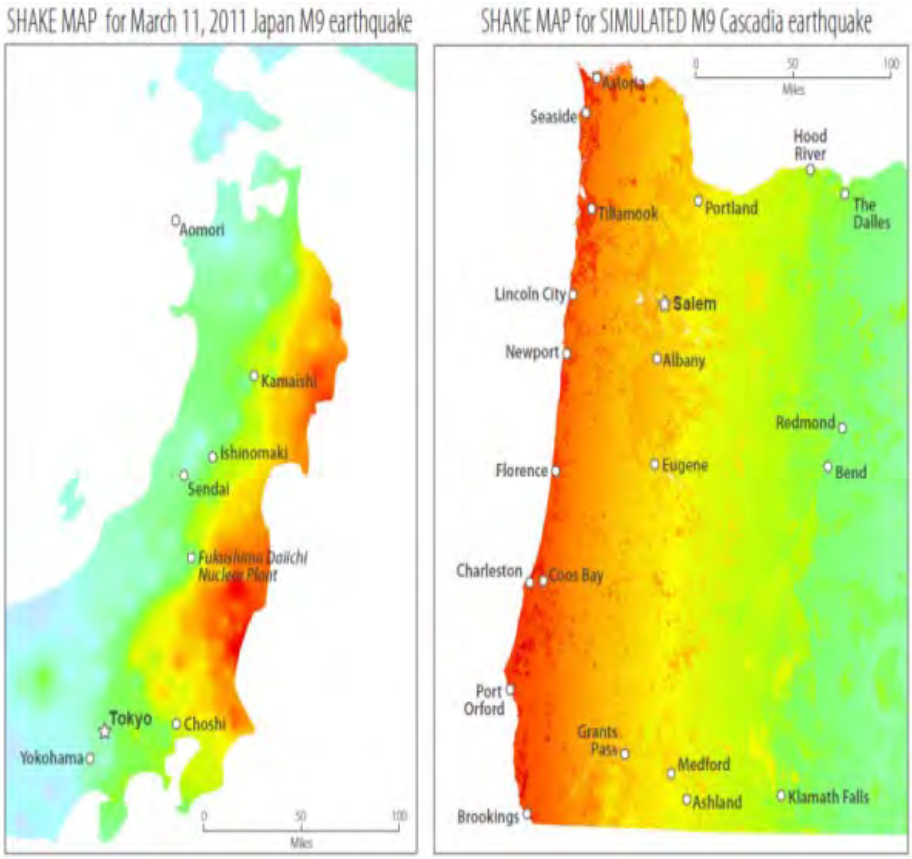
Table 2-EQ-1 gives an abbreviated description of the 12 levels of Modified Mercalli intensity.

Table 2-EQ-1: 12 levels of Modified Mercalli intensity

I.	Not felt except by a very few under especially favorable conditions.
II.	Felt only by a few persons at rest, especially on upper floors of buildings.
III.	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV.	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V.	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI.	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII.	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII.	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX.	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X.	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI.	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII.	Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Source: Abridged from The Severity of an Earthquake, a U. S. Geological Survey General Interest Publication. U.S. GOVERNMENT PRINTING OFFICE: 1989-288-913

Future megathrust earthquakes on the Cascadia Subduction Zone (CSZ) will occur off the coast, and the strength of shaking will decrease inland. Oregon coastal communities will experience severe shaking, but the Portland area and Willamette Valley communities are far enough inland that they will feel much less shaking. Because of the size of the megathrust fault, the shaking will impact all of Oregon west of the Cascades, and will still be felt to the east of the Cascades, and will extend to northern California and British Columbia. The other unique characteristic of megathrust earthquakes is that the strong shaking will last for several minutes, in contrast to a large crustal earthquake, which might shake for only 30 seconds. The long duration of shaking contributes greatly to damage, as structures go through repeated cycles of shaking. Figure 2-EQ-7 shows a side-by-side comparison of ShakMaps for 1) the 2011 M9 Earthquake in Japan, and 2) a simulated M9 CSZ event in Oregon.

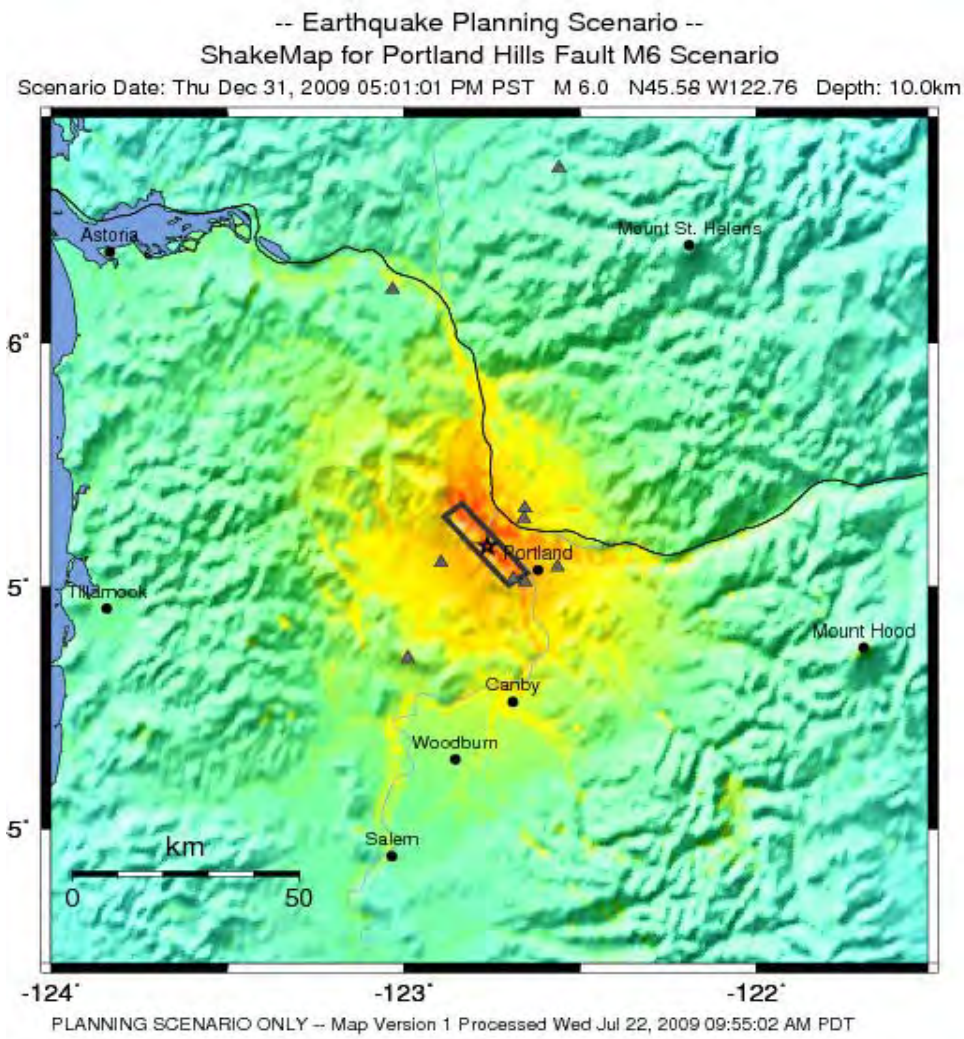


PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Figure 2-EQ-7: Comparison of measured shaking from Tohoku earthquake and simulated shaking from M 9 Cascadia megathrust earthquake.

Source: USGS

Future crustal earthquakes will occur along one of many Oregon fault lines, and the shaking will be strongest near the epicenter, and will decrease fairly quickly as you move away. So a magnitude 6 earthquake in Klamath Falls may cause significant damage near the epicenter, but will be only weakly felt in Medford or Eugene. Figure EQ-8 shows a M6 crustal fault ShakeMap scenario along the Portland Hills fault.



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Figure 2-EQ-8: Simulated shaking from M 6.0 crustal earthquake on the Portland Hills Fault.

Source: USGS

The other important factor in controlling earthquake damage is the contribution of local geology. Soft soils can strongly amplify shaking, loose saturated sand or silt can liquefy, causing dramatic damage, and new landslides can occur on steep slopes while existing landslide deposits may start to move again (Figure 2-EQ-9). These effects can occur regardless of the earthquake source, and the geologic factors that cause them can be identified in advance by geologic and geotechnical studies. Liquefaction and earthquake induced landslides are both more likely to occur during the several minutes of shaking produced by a megathrust earthquake, and these effects are expected to be widespread during the next event (Figures 2-EQ-10, 11 and 12). In 2013, DOGAMI published a suite of statewide earthquake hazard maps with GIS files in Open File Report O-13-06, including: GROUND MOTION, GROUND DEFORMATION, TSUNAMI INUNDATION, COSEISMIC SUBSIDENCE, AND DAMAGE POTENTIAL MAPS FOR THE 2012 OREGON RESILIENCE PLAN FOR CASCADIA SUBDUCTION ZONE EARTHQUAKES. (2013, Madin and W. Burns). (This report and maps are available at website: http://www.oregongeology.org/pubs/ofr/p-O-13-06.htm.)

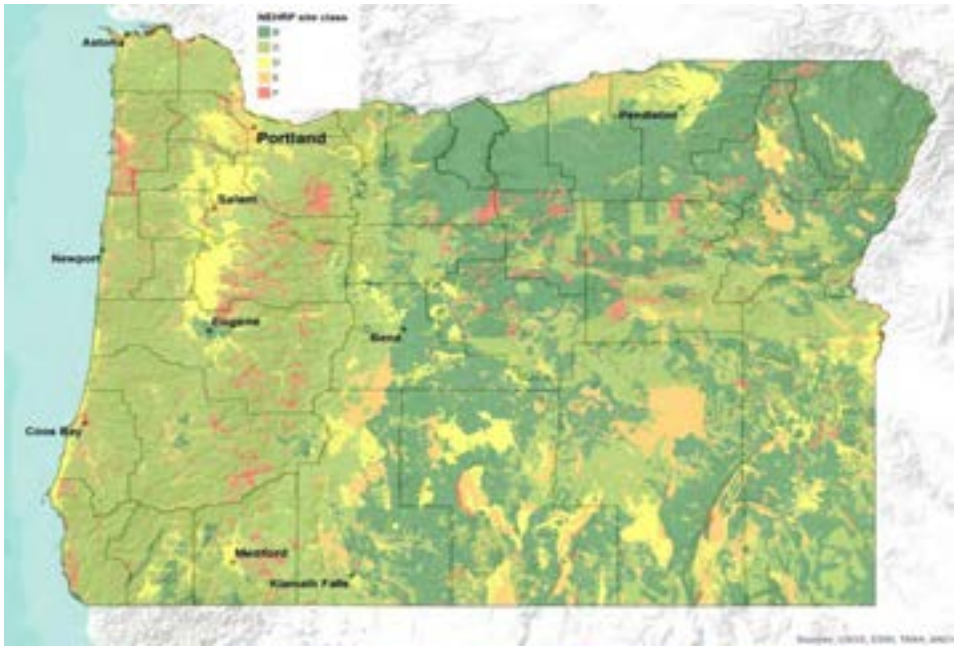


Figure 2-EQ-9: This NEHRP soils map shows areas where soils can amplify the earthquake ground shaking. NEHRP site class F soils are prone to produce the greatest amplification

Source: Madin and Burns, 2013

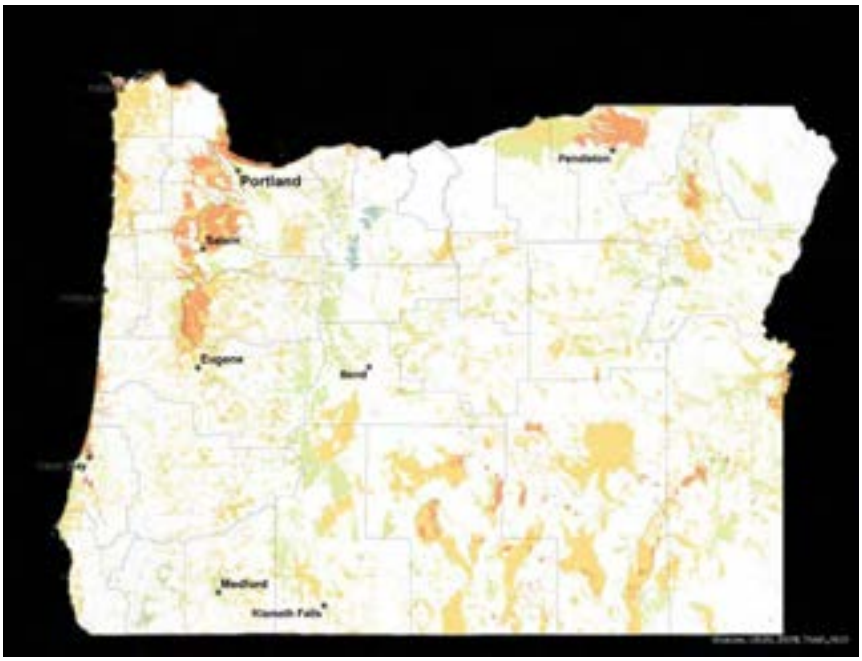


Figure 2-EQ-10: This liquefaction susceptibility map shows areas where soils can liquefy due to the earthquake ground shaking. Areas in red are most prone to liquefy.

Source: Madin and Burns, 2013

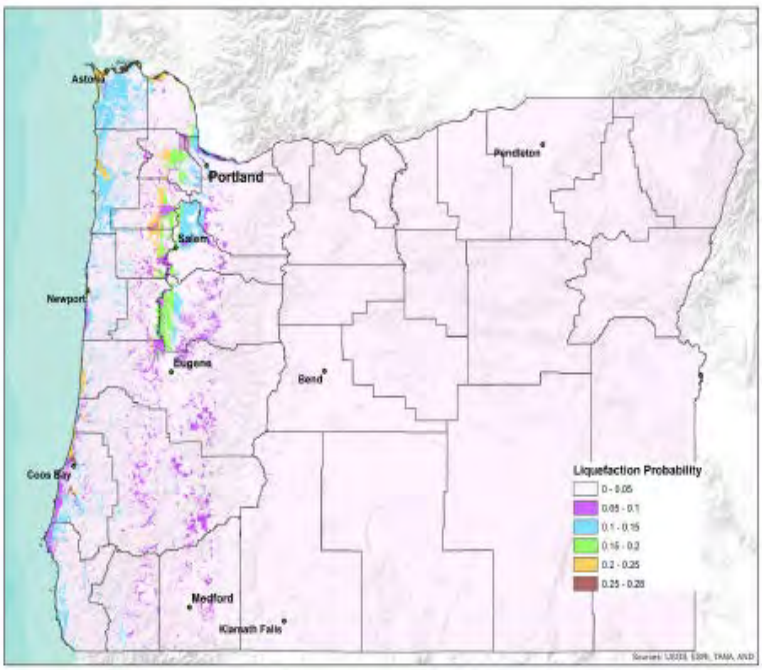


Figure 2-EQ-11: This liquefaction probability map shows the probability of soil liquefaction due to a magnitude 9 Cascadia earthquake. Areas in brown have the highest probability.

Source: Madin and Burns, 2013

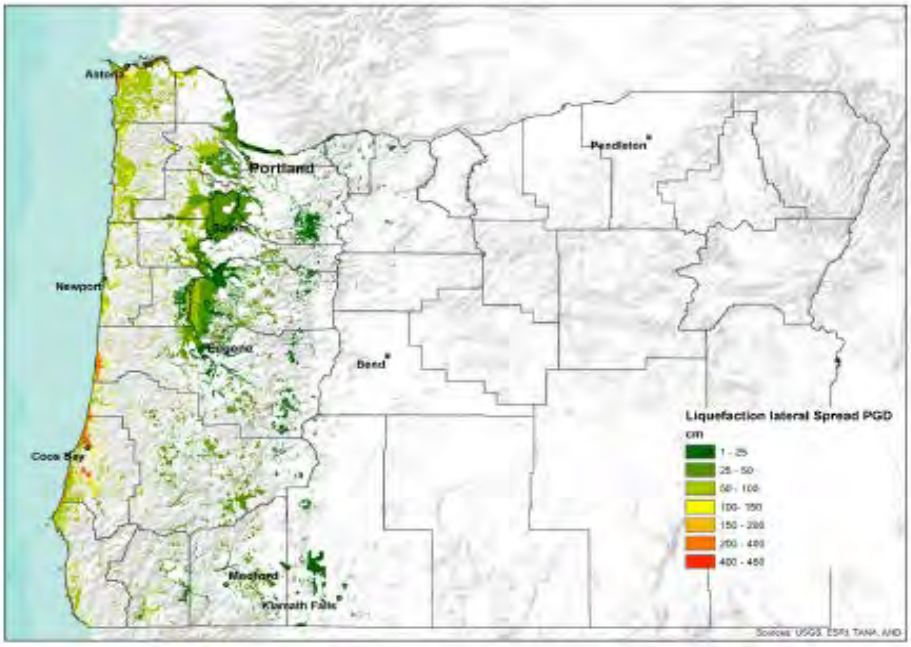


Figure 2-EQ-12: This lateral spreading map shows areas of lateral spreading hazard due to a magnitude 9 Cascadia earthquake. Areas in red have the highest displacement.

Source: Madin and Burns, 2013

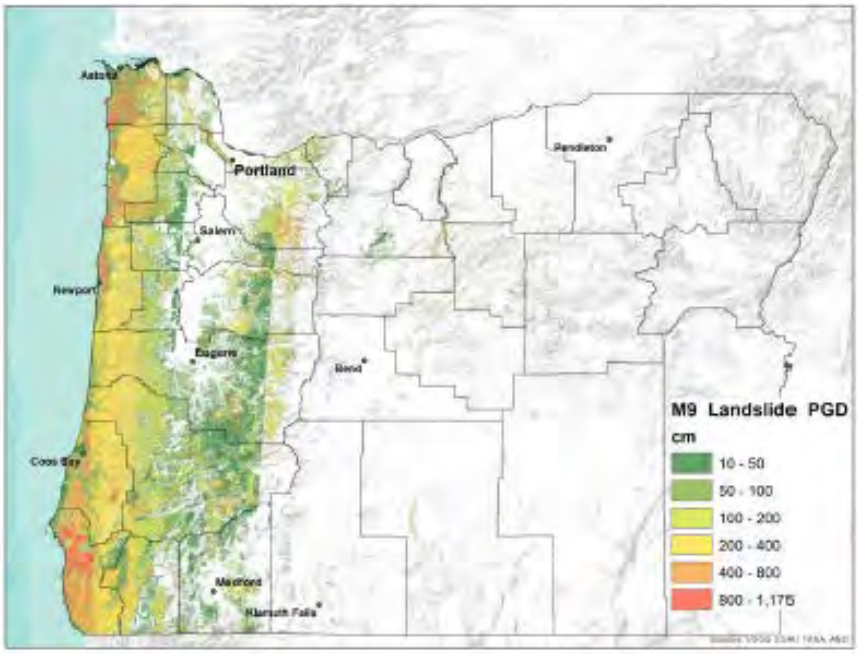


Figure 2-EQ-13: This landslide hazard map shows areas and amount of expected displacement due to a magnitude 9 Cascadia earthquake. Areas in red have the highest displacement.

Source: Madin and Burns, 2013

Historic Earthquakes in Oregon

Figure 2-EQ-14 shows the history of the CSZ megathrust activity in the Pacific Northwest over the past 10,000 years. Table XX lists historic earthquakes in Oregon from both CSZ events and combined crustal events.

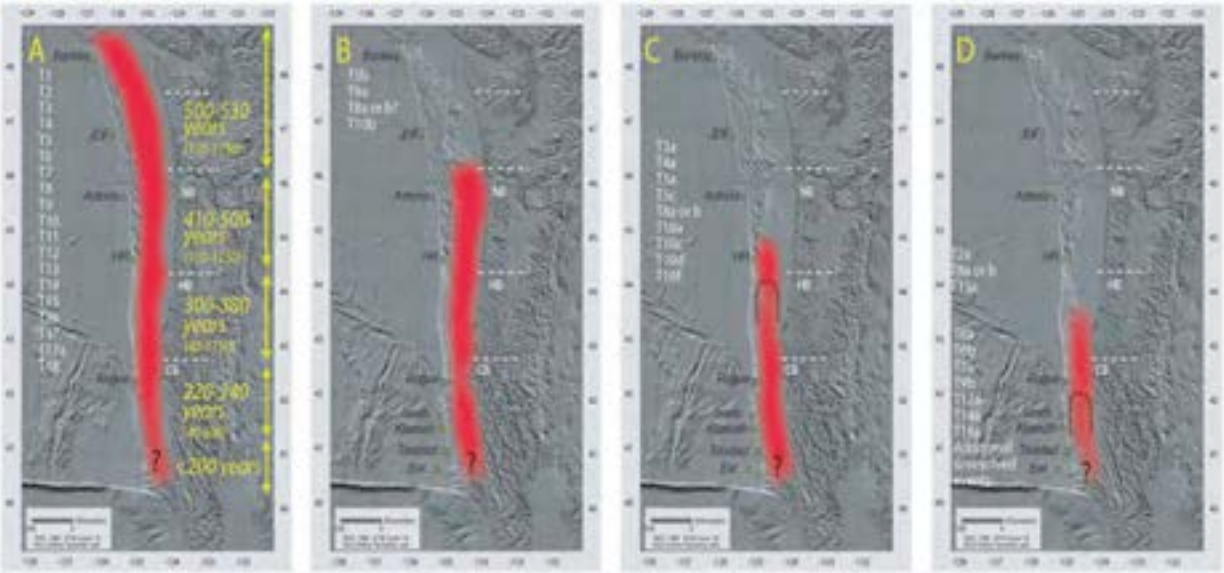


Figure 2-EQ-14: Summary diagram showing Cascadia megathrust earthquake history over the last 10,000 years, "T" numbers identify individual earthquakes. Four distinct modes are seen, ranging from the 19 full-length ruptures in panel A (~M 9) to the 10 smaller ruptures in panel D.

Source: Goldfinger and others, 2011.

Table 2-EQ-2: Historic Earthquakes in Oregon

Date	Location	Description
1873*	Del Norte County, CA	Felt in Portland. Localized chimney damage as far north as Port Orford, Oregon.
1877*	Portland, OR	Intensity Vii. Chimney damage
1892*	Portland, OR	Intensity VI. Affected area: 26,000 square. Buildings swayed, people terrified and rushed into the street. Felt in Astoria and Salem.
1893*	Umatilla, OR	Intensity VI-VII. Damage to buildings in Umatilla.
1896*	McMinneville, OR	Intensity VI. Three shocks in succession in McMinnville . Main shock felt at Portland and Salem.
1906*	Paisley, OR	Intensity V. Three additional shocks followed within 1 1/2 hours.
1913*	Seven Devil's Mountains of western Idaho	Intensity V. Broke windows and dishes.
1915*	Portland, OR	Intensity V. Three shocks reported. Rattled dishes, rocked chairs, and caused fright at Portland.
1923*	Southern Oregon	Intensity V. Plaster fell at Alturas, California. Tremor felt at Lakeview, Oregon
April 8, 1927*	Eastern Baker County, OR	Maximum intensity V (Halfway and Richland). Center: eastern Baker County. Felt widely over eastern Oregon.
July 15 – November , 1936*	Milton-Freewater, OR	Intensity VII. Magnitude 5.75. Center: near the State line between Milton-Freewater, Oregon, and Walla Walla, Washington. Affected area: 272,000 square kilometers in the two States, and Idaho. Ground cracking observed 6.5 kilometers west of Freewater. Marked changes in flow of well water (). Chimneys damaged, plaster broken and walls cracked in Freewaterand Umapine. Total damage : $100,000. Numerous aftershocks up to November 17 (more than 20 moderate shocks during the night, and stronger ones (V) on July 18 and August 4 and 27.
Dec,ber 29, 1941*	Portland, OR	Intensity VI. Affected area: 13,000 square kilometers (Portland). Felt at Hillsboro, Sherwood, Yamhill,and into Washington (Vancouver and Woodland). Windows broken.
April 13, 1941*	Olympia, WA	Magnitude 7.0. At Olympia, Washington, and a broad area around the capital city. Fatalities: 8. Damage: $25 million . Affected area: 388,000 square kilometers. Damage: widespread (Oregon); injuries: several (Astoria and Portland). Maximum intensity: VIII (Clatskanie and Rainier); chimneys twisted and fell;damage to brick and masonry.
December 15, 1953*	Portland, OR	Intensity: VI. Minor damage (Portland area). Affected area: 7,700 square kilometers . One cracked chimney and slight damage to fireplace tile. Plaster cracking (Portland and Roy, OR and Vancouver, WA).
November 16, 1957*	Salem, OR	Intensity VI. Affected area: 11,600 square kilometers (northwestern Oregon). Frightened all in the city and cracked plaster (West Salem).
August 18, 1961*	Albany/Lebanon, OR	Intensity VI. Magnitude 4.5 . Affected area: 18,000 square kilometers. Felt region extended into Cowlitz County, Washington. Damage: minor (Albany and Lebanon, south of the 1957 center Felt in both cities. Two house chimneys toppled, and plaster cracked.
November 6, 1961*	Portland, OR	Intensity VI. Affected area: 23,000 square kilometers (northwestern Oregon and southwestern Washington). Principle damage: plaster

		cracking. Part of a chimney fell, and windows and lights broke.
May 26 – June 11, 1968*	Oregon/California border	Intensity: VI. Magnitude: 4.7. Affected area: 18,000 square kilometers (in the two states).A series of earthquakes near the Oregon-California border. Chimneys fell or cracked, and part of an old rock cellar wall fell. Ground fissures in Bidwell Creek Canyon, near Fort Bidwell, California.
1993**	Scott's Mills, OR	5.7 Mw. Largest earthquake since 1981. Felt from Puget Sound to Roseburg, OR, †,
1993***	Klamath Falls, OR	5.9 Mw & 6.0 Mw. ***Affected area: 130,000 sq km (southwestern Oregon and northern California). Losses: concentrated in downtown area. Intensity VII in downtown Klamath Falls and immediate vicinity and to the Oregon Institute of Technology, but surrounding experienced intensity VI. ††, Fatalities: Two.
2001**	Nisqually, WA	Felt as far south as central Oregon

Sources: * USGS. *Oregon Earthquake History*. Retrieved October 28, 2013, http://earthquake.usgs.gov/earthquakes/states/oregon/history.php
USGS. *Earthquake Archive*. Retrieved October 28, 2013, http://earthquake.usgs.gov/earthquakes/search/

*** - Sherrod, D. R. (1993). Historic and Prehistoric Earthquakes Near Klamath Falls, Oregon. Earthquakes & Volcanoes, 24(3), 106.

† - Thomas, G. C., Crosson, R. S., Carver, D. L., and Yelin, T. S. (1996). The 25 March 1993 Scotts Mills, Oregon, Earthquake and Aftershock Sequence: Spatial Distribution, Focal Mechanisms, and the Mount Angel Fault. Bulletin of the Seismological Society of America, 86(4). 925-935.

†† - Dewey, J. W. (1993). Damages from the 20 September Earthquakes Near Klamath Falls, Oregon. Earthquakes & Volcanoes, 24(3), 121.

††† - Bott, J. D., & Wong, I. G. (1993). Historical earthquakes in and around Portland, Oregon. *Oregon Geology*, *55*(5), 116-122.

Probability

The probability of damaging earthquakes varies widely across the state. In Coastal and Western Oregon, the hazard is dominated by Cascadia subduction earthquakes originating from a single fault with a well understood recurrence history. For eastern Oregon the hazard is dominated by numerous crustal faults and background seismicity, with poorly understood probability that varies from region to region. The probability of earthquake hazards occurring in Oregon is defined in two ways. Figure 2-EQ-15 shows the probabilistic hazard for the entire state. This map shows the expected level of earthquake damage that has a 2 percent chance of occurring in the next 50 years. The map is based on the 2008 USGS National Seismic Hazard Map, and has been adjusted to account for the effects of soils following the methods of Madin and Burns, 2013. In this case, the strength of shaking, calculated as peak ground acceleration and peak ground velocity, have been expressed as Mercalli intensity, which describes the effects of shaking on people and structures, and is more readily understandable for a general audience. These maps incorporate all that is known about the probabilities of earthquake on all Oregon faults, including the Cascadia Subduction Zone.

For Oregon west of the crest of the Cascades, the Cascadia subduction zone is responsible for most of the hazard, as shown in Figure 2-EQ-15. The paleoseismic record includes 18 M_W 8.8-M 9.1 megathrust earthquakes in the last 10,000 years that affected the entire subduction zone. The return period for the largest earthquakes is 530 years, and the probability of the next such event occurring in the next 50 years ranges from 7-12%. An additional 10-20 smaller M_W 8.3-8.5 earthquakes only affected the southern half of Oregon and northern California. The average return period for these is about 240 years, and the probability of a small or large subduction earthquake occurring in the next 50 years is 37-43%.

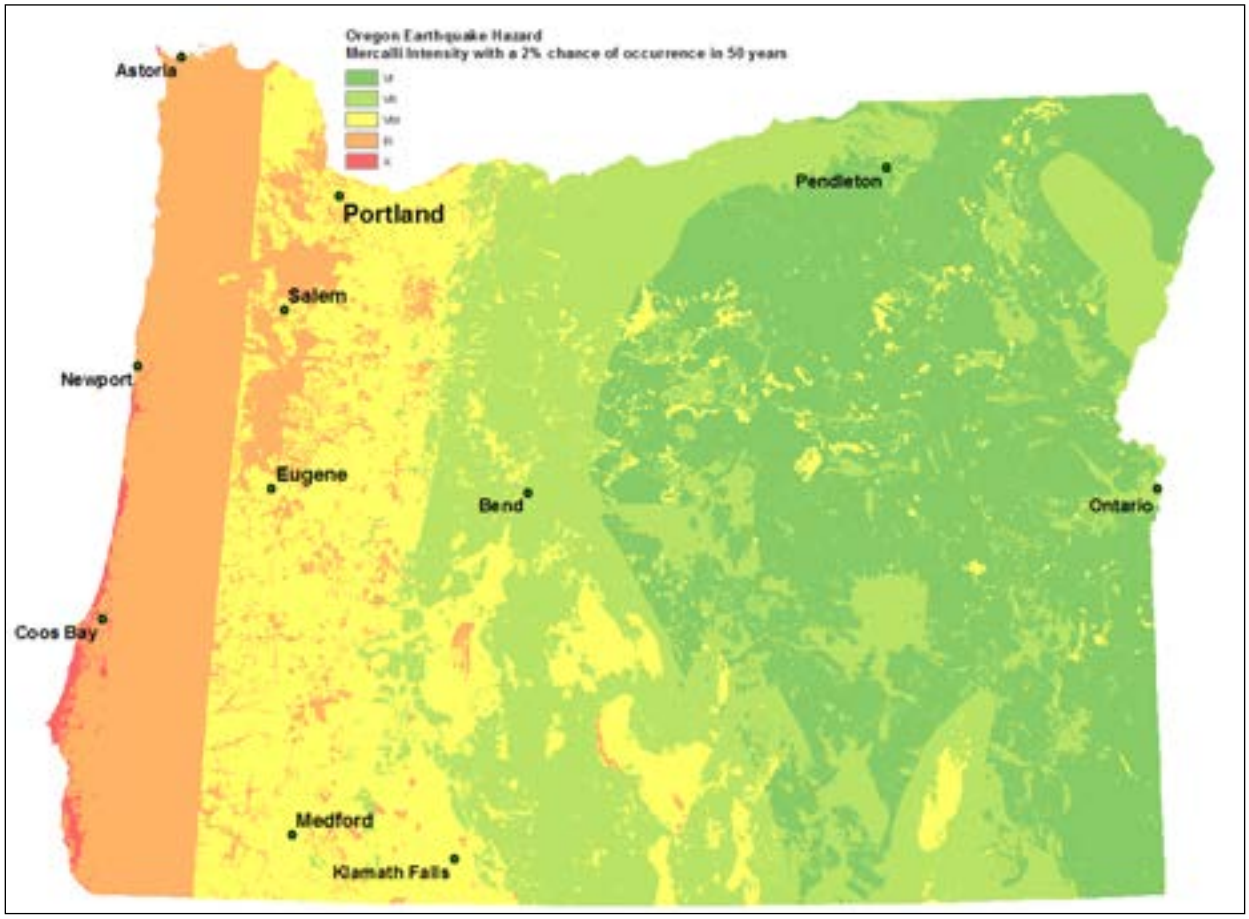


Figure 2-EQ-15: Statewide Probabilistic Earthquake Hazard. Color zones show the maximum level of earthquake shaking and damage (Mercalli Intensity Scale) expected with a 2% chance of occurrence in the next 50 years. A simplified explanation of the Mercalli levels is:

- VI Felt by all, weak buildings cracked
- VII Chimneys break, weak buildings damaged, better buildings cracked
- VIII Partial collapse of weak buildings, unsecured wood frame houses move
- IX Collapse and severe damage to weak buildings, damage to wood-frame structures
- X Poorly built structures destroyed, heavy damage in well-built structures

Source: DOGAMI

Flood

Floods are a common and widespread natural hazard in Oregon; the state has an extensive history of flooding (Figure 2-FL-1).

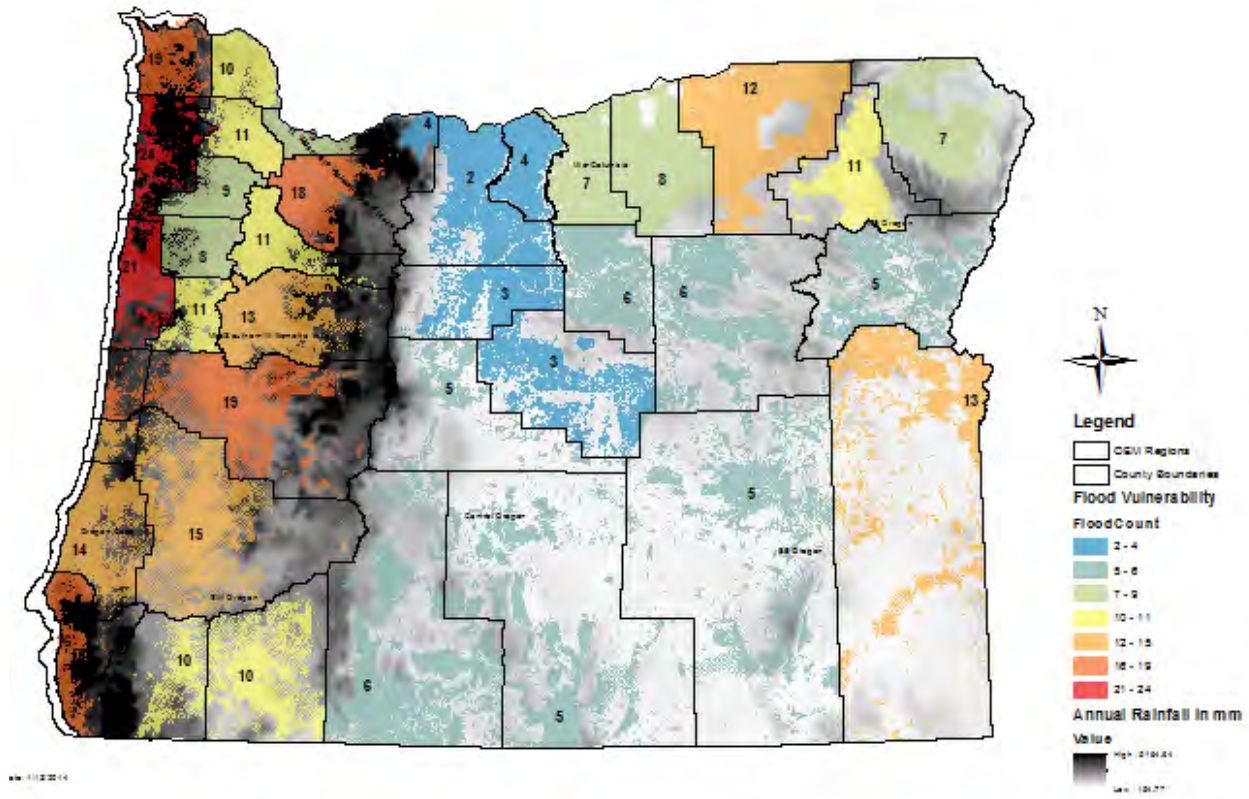


Figure 2-FL-1: Number of damaging flood events by County since 1978. The frequency of damaging floods overlaid upon annual precipitation (mm). Damaging floods only depicted on lands in private ownership.

Source: DLCD

The National Flood Insurance Program (NFIP) identifies 251 communities in Oregon as flood-prone including locations in all 36 counties, 212 cities, and 3 tribal nations. Every county and all but two of these flood-prone cities belong to the NFIP, allowing residents to purchase flood insurance. Nine additional cities for which FEMA has not mapped Special Flood Hazard Areas also belong to the NFIP. Flooding typically results from large-scale weather systems that generate prolonged rainfall or rain on snow events that result in large amounts of runoff. Other sources of flooding include flash floods associated with locally intense thunderstorms, ice or debris jams, and much less frequently dam failures.

Hazard Analysis and Characterization

History of Flooding in Oregon

Oregon has an extensive history of flooding. Tables 2-FL-1 and 2-FL-2 summarize major floods within the state. Oregon's deadliest recorded flood occurred in Heppner in 1903 when a June 14th storm dropped 1.5 inches of rain within a twenty-minute period. The storm was centered in the headwaters area of Willow Creek above Heppner in Northeastern Oregon. Within minutes, a five-foot wall of water and debris poured through Heppner with enough velocity to rip homes off foundations. These floodwaters claimed 247 lives.[23]

The late spring 1948 flooding is best remembered for destroying the entire city of Vanport (now Delta Park). Record flow levels on the Columbia River caused the structural failure of a dike. Much of Vanport was destroyed in minutes and was never rebuilt. Nineteen thousand people lost their homes and eighteen people lost their lives.

Many of Oregon's flood records were set in December 1964 and January 1965 during the "Christmas Flood." Damage from these floods totaled over $157 million dollars and twenty Oregonians lost their lives. From December 20 through 24, 1964, the most severe rainstorm to occur in Central Oregon and one of the most severe west of the Cascades left many areas with two-thirds their normal annual rainfall in five days. The ensuing floods destroyed hundreds of homes and businesses, forced the evacuation of thousands of people, destroyed at least thirty bridges and washed out hundreds of miles of roads and highways.

A similar flood event occurred in February 1996. Following an extended period of unseasonably cold weather and heavy snowfall in the Pacific Northwest, warming temperatures and rain began thawing the snowpack and frozen rivers throughout Oregon. On February 6, a strong subtropical jet stream or "pineapple express" reached Oregon. This warm, humid air mass brought record rainfall amounts, quickly melting the snowpack. At least twenty-five rivers reached flood stage. Many reached flood levels comparable to those reached in the 1964 flood. Twenty-seven of Oregon's thirty-six counties were eventually covered by a Presidential major disaster declaration due to this event. Statewide, damages totaled over $280 million.

Another regional event took place in December of 2007 when a series of powerful wind and rain storms caused extensive flooding in northwestern Oregon. At least xx3 Oregon rivers reached major flood stage. Three people were killed in Oregon as a result of these storms. [24] The City of Vernonia was hard hit with over 200 buildings substantially damaged and subsequently elevated or bought-out by FEMA. At least five people were killed as a result of these storms.

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[23] See http://www.wrh.noaa.gov/pqr/paststorms/index.php for more information about the 1903 event.

[24] NOAA Service Assessment, Pacific Northwest Storms of December 1 – 3, 2007, September 2008

Types of Flooding

Riverine – Riverine flooding is the most common flood hazard in Oregon. It is caused by the passage of a larger quantity of water than can be contained within the normal stream channel. The increased stream flow is usually caused by extensive rainfall over a period of several days. The most severe flooding conditions generally occur when rainfall is augmented by snowmelt. If the ground is saturated or frozen, stream flow can be increased even more by the inability of the soil to absorb additional precipitation. Examples of riverine events are the flooding in December 2007, February 1996, and December 1964 to January 1965.

Flash Floods – Flash flooding is caused by extremely intense rainfall over a short period of time, commonly within a single drainage. Flash floods usually occur in the summer during the thunderstorm season. The two key contributors to flash flooding are rainfall intensity and duration. Topography, soil conditions and ground cover also impact flooding. Flash floods, because of their intensity, often pick up large loads of sediment and other solid materials. In these situations, a flash flood may arrive as a fast moving wall of debris, mud, and water.

Occasionally, floating debris or ice accumulates at a natural or man-made obstruction and restrict the flow of water. Water held back by the ice jam or debris dam can cause flooding upstream. Subsequent flash flooding can occur downstream if the obstruction suddenly releases. Areas subject to flash floods are not as obvious as a typical riverine floodplain. However, flash floods may be associated with recognizable locations such as canyons or arroyos. There is also always some potential for flash floods associated with dam failure.

The most notorious flash flood in Oregon was the June 14, 1903 event in Heppner summarized previously. More recent flash floods have occurred in Wallowa Co. (July 2002) and the City of Rufus (August 2003).

Coastal Floods – Coastal areas have additional flood hazards. Winds generated by tropical storms or intense off shore low-pressure systems can drive ocean water inland and cause significant flooding. The height of storm surge is dependent on the wind velocity, water depth and the length of open water (the fetch) over which the wind is flowing. Storm surges are also affected by the shape of the coastline and by the height of tides.

Coastal flooding also may result from tsunamis. A tsunami is a series of traveling ocean waves generated by an earthquake or landslide that occurs below or on the ocean floor. Oregon's seven coastal counties and many coastal cities are susceptible to flood damage associated with tsunamis. Both "distant" tsunamis generated from seismic events in the Pacific basin and local tsunamis generated from activity associated with the Cascadia Subduction Zone can impact Oregon's coast. For more information, see the Tsunami Chapter of this plan.

Shallow Area Flooding – Some areas are characterized by FEMA as being subject to shallow flooding. These are areas that are predicted to be inundated by the 100-year flood with flood depths of one to three feet. Flooding events are expected to be low velocity events characterized by "sheet flows" of water.

Urban Flooding – As land is converted from fields or woodlands to roads, roofs, and parking lots, it loses its ability to absorb rainfall. This transition from pervious surfaces to impervious surfaces results in more and faster runoff of water. During periods of urban flooding, streets can become swift moving rivers, and basements can fill with water. Storm drains may back-up with yard waste causing additional nuisance flooding.

Playa Flooding – Playa flooding results from greater than normal runoff into a closed basin. Closed basin systems are those areas that have one or more rivers emptying into one or more lakes that have no outlet. In these situations, water can only leave the system through evaporation. Thus, if annual precipitation in the basin increases significantly, evaporation is not enough to reduce water levels. Lake levels rise and inundate the surrounding properties.

The best-known example of playa basin flooding in Oregon occurs at Malheur and Harney lakes in Harney County. In higher than average precipitation years, the lakes flood adjacent ranches and public roads. Malheur and Harney lakes flooded during the years 1979 to 1986, and then gradually receded. During the wetter years of 1997 to 1999, these lakes again flooded. By 2005, following a number of dry years, they had receded significantly. In spring 2011, as a result of a heavy snowpack and persistent rainfall, Harney Lake's water level increased significantly with flooding observed in low-lying areas.

Channel Migration in Association with Flooding

Channel migration is the process by which streams move laterally over time. It is typically a gradual phenomenon that takes place over many years due to natural processes of erosion and deposition. In some cases, usually associated with flood events, significant channel migration can happen rapidly. In high flood flow events stream channels can "avulse" and shift to occupy a completely new channel. Areas most susceptible to channel migration are transitional zones where steep channels flow from foothills into broad, flat floodplains. The most common physiographic characteristics of a landscape prone to channel migration include moderate channel steepness, moderate to low channel confinement (i.e. valley broadness), and erodible geology.

Channel migration can and has created hazardous conditions within Oregon's developed riparian areas. Rapid migration can undercut structure foundations and damage infrastructure. The upper Sandy River in eastern Clackamas County is an example of where channel migration and development intersect. A recent January 2011 flood resulted in temporary avulsion that washed out a section of Lolo Pass Road and caused bank erosion that damaged and destroyed several homes.

Channel migration is not a standard consideration of the NFIP and has not been mapped systematically in Oregon. The Oregon Department of Geology and Mineral Industries (DOGAMI) recently started mapping channel migration zones (CMZs) for areas with known susceptibility on an ad hoc basis. DOGAMI is mapping CMZs using procedures developed by the Washington Department of Ecology for administration of its regulatory Shoreline Master Program[25]. In Oregon more work is required to identify susceptible areas where detailed channel migration zone mapping is needed.

[25] The State of Washington has included channel migration as a consideration in its regulatory Shoreline Master Programs (http://www.ecy.wa.gov/programs/sea/sma/st_guide/jurisdiction/cmz.html).

El Niño[26] and La Niña Events in Oregon and Relationship to Flooding[27]

One of the most prominent aspects of Oregon's weather and climate is its variability. This variability ranges over many time and space scales, from small-scale phenomena such as wind gusts and localized thunderstorms, to larger-scale features like fronts and storms, to even more prolonged features such as droughts and periods of flooding. Fluctuations occur on multi-seasonal, multi-year, multi-decade and even multi-century time scales. Examples of these longer time-scale fluctuations include an abnormally hot and dry summer, an abnormally cold and snowy winter, a consecutive series of abnormally mild or exceptionally severe winters, and even a mild winter followed by a severe winter. Human inputs into our geophysical environment are also imposing cumulative impacts with measurable changes to global climate, sea-level and even localized weather. These human inputs along with the normal climate cycles may be working together in unpredictable ways and lead to future climate scenarios that do not resemble past, historic cycles. For example, recent research suggests that a warming climate reinforces the possibility that El Niño events could be stronger and more frequent while La Niña episodes may be weaker and less frequent.

The terms El Niño and La Niña represent opposite extremes of the ENSO cycle in an otherwise continuum of global climate events, with "average" conditions generally prevailing between those extremes. In the past three decades there have been several El Niños, with the 1982 to 1983 and 1997 to 1998 events having been the strongest on record, while the period between 1990 and 1995 was characterized by persistent El Niño conditions, the longest on record. (Trenberth, 1999)

In general, the longer time-scale phenomena are associated with changes in oceanic and atmospheric circulation that encompass areas far larger than a particular affected region. At times, these persistent features occur simultaneously over vast, and seemingly unrelated, parts of the hemisphere, or even the globe, resulting in abnormal weather, temperature and rainfall patterns throughout the world. During the past several decades, scientists have discovered that important aspects of this interannual variability in global weather patterns are linked to a global-scale, naturally occurring phenomenon known as the El Niño Southern Oscillation (ENSO) cycle. A measure of this cycle is the Southern Oscillation Index (SOI), which is "calculated from the monthly or seasonal fluctuations in the air pressure difference between Tahiti and Darwin, Australia."

> Additional information regarding the relationship between ENSO – especially El Niño years – and related coastal hazards may be found in the Coastal Erosion Chapter of this plan.

The ENSO cycle is caused by periodic changes in atmospheric pressure differences in the South Pacific Ocean. These changes then cause a periodic rise or fall in Pacific Ocean equatorial sea surface temperatures. The abnormal temperatures affect atmospheric conditions impacting the weather of a large portion of the world, including Oregon. The interaction of the abnormal sea surface temperatures

[26] The cyclical warming of east Pacific Ocean seawater temperatures off the western coast of South America that can result in significant changes in weather patterns in the United States and elsewhere.

[27] In large part from Impacts of the El Niño/Southern Oscillation on the Pacific Northwest, George Taylor, OCS, March 1998, http://www.ocs.orst.edu/reports/enso_pnw.html

and the atmosphere affect the position and intensity of the polar and sub-tropical jet streams, which in turn determine the intensity and track of storms.

Historical El Niño and La Niña Events In Oregon

The earliest systematic study of ENSO in the Northwest was Redmond and Koch (1991). The results were sufficiently strong that the authors suggested a cause-effect relationship between the SOI and Oregon weather. They determined that the Southern Oscillation Index (SOI) can be used as a predictor for weather, especially for winter weather. Greatest correlations between SOI and winter weather patterns occur with about a four-month time lag with summer average SOI correlating well with weather in the Northwest during the following winter. SOI values less than zero represent El Niño conditions, near zero values are average, and positive values represent La Niña conditions.

El Niño Events	La Niña Events
1982-1983	1988-1989
1994-1995	1995-1996
1997-1998	1999-2000
2002-2003	
2004-2005	
2006-2007	2007-2009
2009-2010	2010-2012

Table 2-FL-1:
Recent ENSO events in Oregon

Source: http://www.esrl.noaa.gov/psd/enso/mei/

In Oregon El Niño impacts associated with these climate features generally include warmer winter temperatures and reduced precipitation with drought conditions in extreme events.

What Oregonians should especially plan for and monitor, however, is La Niña. Severe flooding during the winters of 1995-96, 1998-99, and 2007-08 are attributable largely to the combination of heavy snows and warm, intense tropical rain. During La Niña events, heavy rain arrives in Oregon from the western tropical Pacific, where ocean temperatures are well above normal, causing greater evaporation, more extensive clouds, and a greater push of clouds across the Pacific toward Oregon. During February 1996, for example, severe flooding – the worst in the state since 1964 – killed several people and caused widespread property damage. Nearly every river in Oregon reached or exceeded flood stage, some setting all-time records. Debris flows[28] and landslides were also numerous.

[28] These events are typically associated with periods of heavy rainfall or rapid snowmelt on steeply sloping ground. The term “mudslide” is often used interchangeably but is poorly defined as a natural hazard. FEMA uses the terms “mudslide” and “mudflow” in the context of the National Flood Insurance Program, e.g., 44 CFR 59.1 and 206.2(a)(17).

Historic Flood Events in Oregon

Table 2-FL-2 lists historic damaging floods in Oregon.

Table 2-FL-2: Historic Damaging Floods in Oregon

Date	Location	Notes
September 1861	Klamath, Willamette, and Umpqua	
June 1880	Columbia	
January 1881	Willamette Basin	
December 1882	Umatilla	
June 1884	John Day	
May - June 1894	Columbia River Basin	Rain on snowpack; highest flood stage ever recorded at Vancouver, WA (33.6 feet)
June 1903	Willow Creek	Flash flood in Heppner; 247 people killed
April 1904	Silvies and Klamath	
February 1907	Western Oregon and John Day	
November 1909	Deschutes, Willamette, Santiam, Umpqua, Coquille, and Rogue	
March 1910	Powder and Malheur	
June 1913	Columbia	
January 1923	Clackamas, Santiam, Sandy, Deschutes, Hood, and McKenzie	Record flood levels
February 1925	Malheur	
February 1927	Klamath, Willamette, Umpqua, Rogue, and Illinois	Major flooding
May 1928	Columbia	
March 1931	Umatilla, Sandy, Clackamas, and Santiam	
March 1932	Malheur, Grande Ronde, John Day, and Umpqua	
January 1933	Coquille	
November - December 1942	Willamette Basin	10 deaths; $34 million damage
December 1945	Coquille, Santiam, Rogue, and McKenzie	9 deaths and homes destroyed in Eugene area
December 1946	Willamette, Clackamas, Luckiamute, and Santiam	

May - June 1948	Columbia River	Rain on snow; destruction of the City of Vanport
March 1952	Malheur, Grand Ronde, and John Day	Highest flood stages on these rivers in 40 years
December 1955	Rogue, Umpqua, Coquille	11 deaths; major property damage
July 1956	Central Oregon	Flash floods
February 1957	Southeastern Oregon	$3.2 million in flood damages
December 1961	Willamette Basin	$3.8 million in flood damages
December 1964 - January 1965	Pacific Northwest	Rain on snow; record flood on many rivers
December 1967	Central Oregon Coast	Storm surge
January 1972	Western Oregon	Record flows on coastal rivers
January 1974	Western Oregon	$65 million in damages
November - December 1977	Western Oregon	Rain on snow event; $16.5 million in damages
1979 to present	Harney County	Cyclical playa flooding on Harney & Malheur lakes
December 1981	Umpqua and Coquille	
January 1982	Tillamook County	
February 1982	Malheur and Owyhee Basins	
January 1990	Clatsop and Tillamook counties	
July 1995	Fifteenmile Creek	Flash flood in Wasco County (DR-1061)
February 1996	Nearly statewide	Damages totaling over $280 million (DR-1099)
November 1996	Southwest Oregon	Flooding, landslides, and debris flows; eight deaths in Douglas County (DR-1149)
January 1997	Southwest and Northeast Oregon	(DR-1160)
May - June 1998	Crook County and Prineville	Ochoco River (DR-1221)
December 1998	Lincoln and Tillamook counties	
November 1999	Coastal rivers in Lincoln and Tillamook counties	Heavy rainfall and high tides
July 2002	Wallowa County	Flash flood above Wallowa Lake damaged Boy Scout Camp facility
August 2003	City of Rufus	Flash flood (Gerking Canyon)
December 2005 - January 2006	Western and Central Oregon, Malheur County	Multiple heavy precipitation events on snow and/or saturated or frozen ground (DR-1672)
November 2006	Clatsop, Hood River, Lincoln, and Tillamook Counties	Heavy precipitation and wind resulted in flooding, landslides, and mudslides (DR-1672)
February 2007	Western and Central Oregon, and the Confederated Tribes of the Siletz Indians	Severe winter storm and flooding (DR-1683)

December 2007	Northwestern Oregon, Southern Coast	Heavy precipitation and wind resulted in flooding, landslides, mudslides, and tree blow down. (DR-1733)
December 2008	Tillamook County	Flooding caused by convergence of heavy precipitation and high tides
January 2009	Tillamook and Washington Counties	Severe winter storm/snow event which included snow, high winds, freezing rain, ice, blizzard conditions, mudslides, and landslide (flooding, post DR-1824)
January 2011	Clackamas, Clatsop, Crook, Douglas, Lincoln, and Tillamook Counties	Severe winter storm, flooding, mudslides, landslides, and debris flows (DR-1956)
May – June 2011	Union and Grant Counties	Melting heavy snowpack caused riverine and playa flooding
June 2011	Heppner	Persistent showers with heavy rainfall of 1 to 2 inches produced flooding on Willow and Hinton Creeks. Flash flooding on Hinton and Willow Creeks damaged roads, bridges, and the Morrow County Fairgrounds. The Heppner elementary school was evacuated as a precaution.
January 2012	Columbia, Hood River, Tillamook, Polk, Marion, Yamhill, Lincoln, Benton, Linn, Lane, Douglas, Coos, Curry	Heavy rain and wind; ice (DR-4055). Flooding in the Willamette Valley. 130 homes and seven businesses were damaged in the City of Turner. Twenty-nine streets were closed in the City of Salem. The state Motor Pool lost 150 vehicles and thousands of gallons of fuel. Thomas Creek in the City of Scio overtopped, damaging several buildings.
November 2012	Curry , Josephine, and Lane Counties	Heavy precipitation. The Curry Coastal Pilot reported over 2 million dollars in infrastructure damage in Brookings and another 2 million in Curry County due to recent heavy rains. Sinkholes and overflowing sewage facilities were also reported. According to KVAL news, Eugene Public Works has opened its emergency command center to deal with numerous flooding incidents, including two flooded intersections.
September 2013	Multnomah and Tillamook Counties	Heavy rain resulted in flooding of the Wilson River near Tillamook as well as urban flooding in the Portland metro area. KPTV-KPDX Broadcasting reported that heavy

		rain resulted in flooding and damage to the Legacy Good Samaritan Medical Center and several businesses in Northwest Portland. Besides damage to the hospital's emergency and operating room, some elective surgeries were cancelled.

Source: FEMA and NOAA Storm Events Database (http://www.ncdc.noaa.gov/stormevents/)

Probability

Flood risk or probability is generally expressed by frequency of occurrence. Since 1960 one or more damaging floods have occurred somewhere in Oregon in 42 of 52 years reported by NOAA[29].

Probability of flooding is measured as the average recurrence interval of a flood of a given size and place. It is stated as the percent chance that a flood of a certain magnitude or greater will occur at a particular location in any given year. FEMA's NFIP extends regulation to an area covered by the "base flood", a flood that has a 1% chance of occurring in any year. It is important to recognize, however, that floods occur more frequently near the flooding source. Information regarding the probability of flooding at a given location in the regulated flood zones is provided by Flood Insurance Studies (FIS) and Flood Insurance Rate Maps (FIRMs) produced for the NFIP for large watersheds. The FIS presents flood elevations for events with a 10 and 2 percent annual chance of occurring in any given year, but associated flood inundation area is not mapped. FEMA does not provide information about floods emanating from small watersheds (less than one square mile), or for floods caused by local drainage issues. Probabilities for these types of flood are, as a result, difficult to report.

The majority of flood studies in Oregon were conducted in the late 1970s and early 1980s. These studies represent flood risk at a point in time and don't reflect changing conditions in the watershed. Many of Oregon's metropolitan areas have significantly developed during the past twenty years resulting in increased impervious surface which causes higher velocities and increased volume of water. While FEMA's Map Modernization Program did result in updated FIRMs for 14 Counties, many of these maps were produced using models from old flood insurance studies. Whether or by how much these old models underestimate current flood potential is unknown.[30]

Despite the shortcomings of NFIP FIRMs, most Oregon communities exclusively rely on them to characterize the risk of flooding and the land identified likely to flood. Some jurisdictions use their own flood hazard maps derived from aerial photos of past flood events in conjunction with FEMA FIRMs to better reflect their communities' flood risks. Others have implemented a higher regulatory standard to address changing conditions; for example Metro's balanced cut and fill requirements, and Tillamook

[29] NOAA Storm Events Database

[31] BFE is the projected depth of floodwater at the peak of a base flood, generally measured as feet above sea level.

County's and the City of Vernonia's requirement that new homes and substantial improvements to existing homes be elevated at least three feet above base flood elevation (BFE).[31]

Channel migration associated with flooding is commonly identified with respect to a probability of migration over a period of 100 years. Historic aerial photos are catalogued to calculate past rates of migration which are then projected out to define a CMZ. Avulsion (i.e. channel shifting) zones, which are a component of the larger CMZ, are an exception to the migration rate approach. Areas of likely avulsion are identified by professional judgment of a fluvial geomorphologist, using high-resolution topographic data, aerial photos, and field observation.

Identification of channel migration susceptibility at the regional level is described in terms of low, moderate, and high relative probabilities. Probability is determined by assessing physiographic parameters of channel gradient, confinement and pattern.

[31] BFE is the projected depth of floodwater at the peak of a base flood, generally measured as feet above sea level.

Landslides

Landslides can be found throughout the state of Oregon, as seen in the current statewide landslide inventory database, SLIDO-2, in Figure 2-LS-1 and Table 2-LS-1 below (Burns and others, 2011). Systematic statewide landslide mapping has not been performed, however in general the areas of the state with more relief and steeper slopes, such as the Coast Range Mountains and the Cascade Mountains, tend to have more landslides. In general counties in Oregon have hundreds to thousands of existing landslides as shown in the table below derived from the SLIDO-2 database.

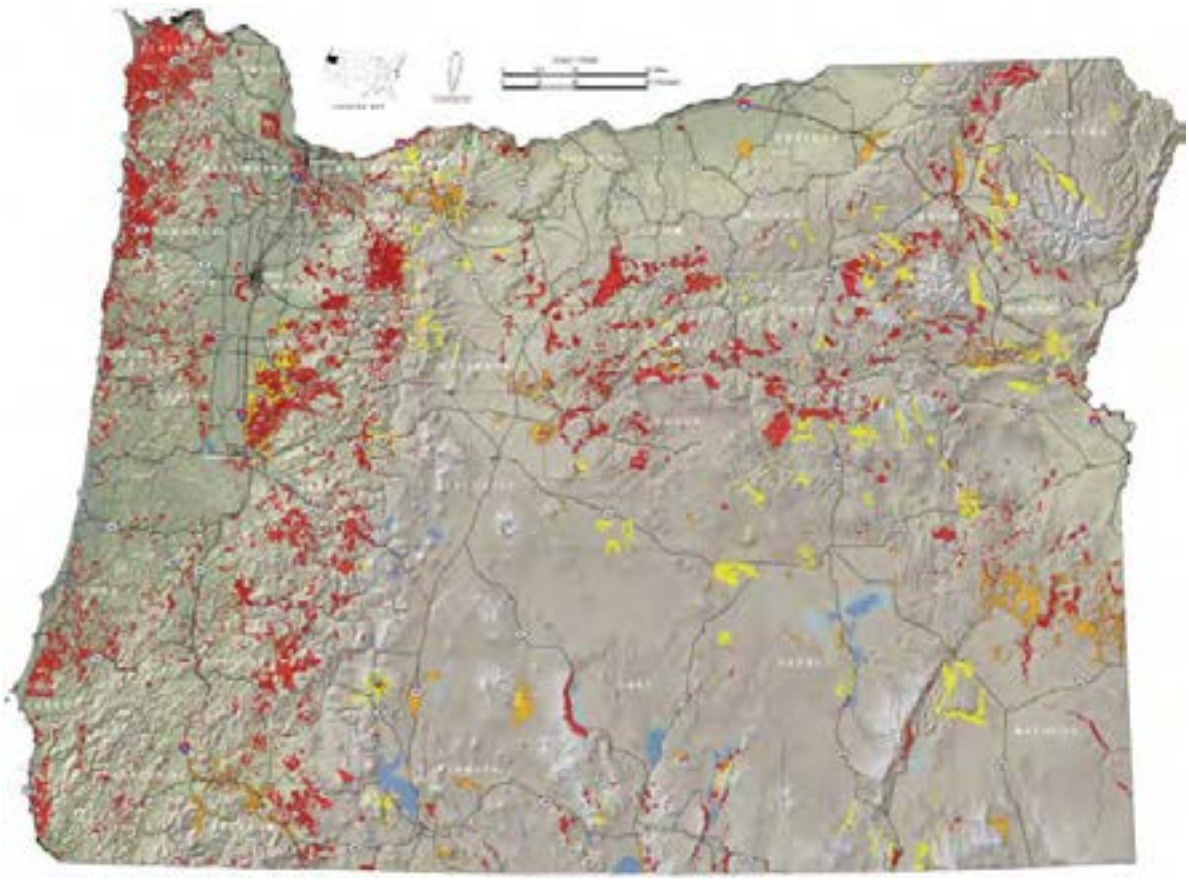

Figure 2-LS-1: Statewide Landslide Inventory

Source: DOGAMI

Burns, W.J., Mickelson, K.A., Saint-Pierre, E.C., 2011. Statewide Landslide Information Database of Oregon Release-2, Oregon Department of Geology and Mineral Industries, SLIDO-2

Note: Clackamas County has many more landslides than most other counties, which is partially because new very detailed lidar based mapping was completed in the NW portion of this county.

County	Number of landslides within and/or touching
Baker County	499
Benton County	885
Clackamas County	3013
Clatsop County	774
Columbia County	212
Coos County	1524
Crook County	397
Curry County	384
Deschutes County	83
Douglas County	1526
Gilliam County	35
Grant County	477
Harney County	435
Hood River County	178
Jackson County	809
Jefferson County	274
Josephine County	380
Klamath County	582
Lake County	204
Lane County	1353
Lincoln County	773
Linn County	1528
Malheur County	737
Marion County	622
Morrow County	56
Multnomah County	1330
Polk County	52
Sherman County	18
Tillamook County	1332
Umatilla County	151
Union County	483
Wallowa County	62
Wasco County	237
Washington County	538
Wheeler County	413
Yamhill County	187

Table 2-LS-1: Number of Landslide Within or Touching Each County in Oregon

Source: Source: Burns and others, 2011

DOGAMI found that in order to truly understand the landslide hazard in Oregon, lidar (light detection and ranging) topographic data must be collected and used during the mapping of existing landslides and modeling of future susceptibility. In fact, DOGAMI estimates that SLIDO-2 is between 0% and 25% capturing the existing landslides in Oregon. This variance in landslide detail can be seen when examining the small NW portion of Clackamas County which has been recently mapped.

One of the most common and devastating geologic hazards in Oregon is landslides. Average annual repair costs for landslides in Oregon exceed $10 million and individual severe winter storm losses can exceed $100 million (Wang and others, 2002). As population growth continues to expand and development into landslide susceptible terrain occurs, greater losses are likely to result.

Landslides in Oregon are typically triggered by periods of heavy rainfall and/or rapid snowmelt. Earthquakes, volcanoes, and human activities also trigger landslides.

There are 3 main factors that influence an area's susceptibility to landslides: geometry of the slope, geologic material, and water. Certain geologic formations are more susceptible to landslides than others. In general, locations with steep slopes are most susceptible to landslides, and the landslides occurring on steep slopes tend to move more rapidly and therefore may pose life safety risks.

Wang, Y., Summers, R.D., and Hofmeister, R.J., 2002, Landslide loss estimation pilot project in Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-02-05, 23 p.

Analysis and Characterization

The term landslide encompasses a wide range of geologic processes and a variety of nomenclatures that can lend itself to confusion. The general term landslide refers to a range of mass movement including rock falls, debris flows, earth slides, and other mass movements. One very important thing to understand is the fact that all landslides have different frequencies of movements, triggering conditions, and very different resulting hazards.

All landslides can be classified into one the following six types of movements: 1) slides, 2) flows, 3) spreads, 4) topples, 5) falls, 6) complex. Most slope failures are complex combinations of these distinct types, but the generalized groupings provide a useful means for framing discussion of the type of hazard associated with the landslide, the landslide characteristics, identification methods, and potential mitigation alternatives.

El Nino Southern Oscillation and Effects on Landslides

The strongest impacts of intra-seasonal variability on the U.S. occur during the winter months over the western U.S. During the winter this region receives the bulk of its annual precipitation. Storms in this region can last for several days or more and are often accompanied by persistent atmospheric circulation features. Of particular concern are the extreme precipitation events which are linked to flooding and landslide. There is strong evidence for a linkage between weather and climate in this region from studies that have related the El Niño-Southern Oscillation (ENSO) to regional precipitation variability. From these studies it is known that extreme precipitation events can occur at all phases of the El Niño-Southern Oscillation (ENSO) cycle, but the largest fraction of these events occur during La Niña episodes and during ENSO-neutral winters. During La Niña episodes much of the Pacific Northwest experiences increased storminess, increased precipitation and more overall days with measurable precipitation. The risk of flooding and rain-induced landslides (and debris flows) in this region can be related to La Niña episodes.

Source: NOAA/Climate Prediction Center
http://www.cpc.noaa.gov/products/intraseasonal/intraseasonal_faq.html#usimpacts

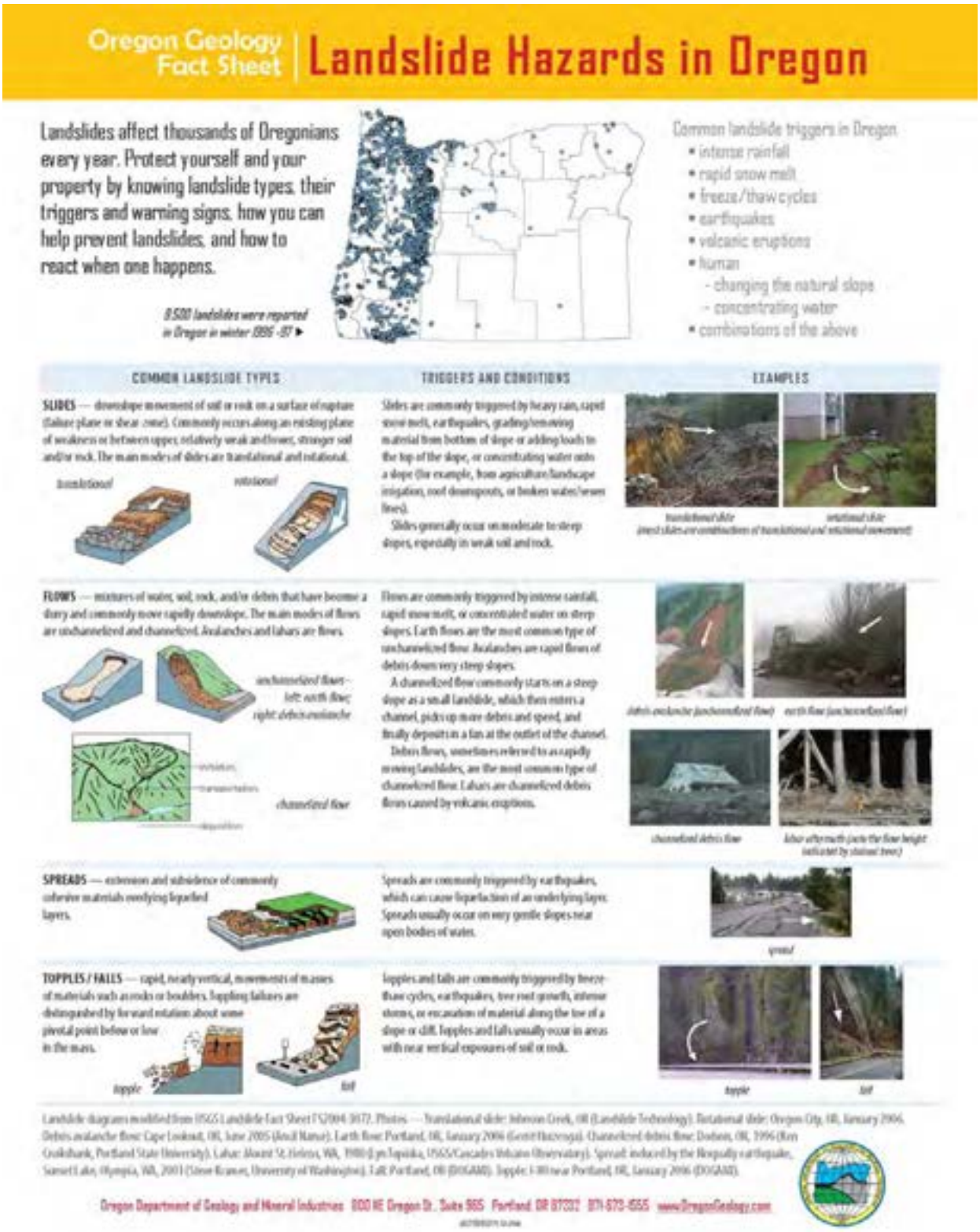

Figure 2-LS-2: Common types of landslides in Oregon.

Source: DOGMI. Website: http://www.oregongeology.org/sub/Landslide/Landslidehome.htm

These types of movements can be combined with other aspects of the landslide such as type of material, rate of movement, depth of failure, and water content for a better understanding of the type of landslide.

One potentially life threatening type of landslide is the channelized debris flow or "rapidly moving landslide" which are flows that initiate upslope, move into or transport down a steep channel (or drainage) and deposit material, usually at the mouth of the channel. Debris flows are also commonly initiated by other types of landslides that occur on slopes near a channel. They can also initiate within the channel in areas of accelerated erosion during heavy rainfall or snowmelt. Rapidly moving landslides have caused most of the recent landslide related injuries and deaths in Oregon. Debris flows or rapidly moving landslides caused eight deaths in Oregon in 1996 following La Niña storms.

Areas that have failed in the past often remain in a weakened state, and many of these areas tend to fail repeatedly over time. This commonly leads to distinctive geomorphology that can be used to identify landslide areas, although over time the geomorphic expression may become subtle, making the landslide difficult to identify. Other types of landslides tend to occur in the same locations and produce distinctive geomorphology, such as channelized debris flows, which form a fan at the mouth of the channel after repeated events. This is also true for the talus slopes, which form after repeated rock fall has taken place in an area.

Previously impacted areas are particularly important to identify, as they may pose a substantial hazard for future instability and help identify areas that are susceptible to future events. Large, slow moving landslides frequently cause significant property damage, but are far less likely to result in serious injuries. Several examples are the subdivision landslide in Kelso, Washington, the slide at The Capes development in Tillamook County, and the apartment complex in Oregon City.

The velocity of landslides varies from imperceptible to over 35 miles per hour. Some volcanic induced landslides have been known to travel between 50 to 150 miles per hour. On less steep slopes, landslides tend to move slowly and cause damage gradually. Debris flows typically start on steep hillsides as shallow landslides, enter a channel, then liquefy and accelerate. Canyon bottoms, stream channels, and outlets of canyons can be particularly hazardous. Landslides can move long distances, sometimes as much as several miles. The Dodson debris flows in 1996 started high on Columbia River Gorge cliffs, and traveled down steep canyons to form debris fans in the Dodson-Warrendale area.

Landslide recurrence interval is highly variable. Some large landslides move continuously at very slow rates. Others move periodically during wet periods. Very steeply sloped areas can have relatively high landslide recurrence intervals (10 to 500 years on an initiation site basis).

Since debris flows can be initiated at many sites over a watershed, in some cases recurrence intervals can be less than ten years. Slope alterations can greatly affect recurrence intervals for all types of landslides, and also cause landslides in areas otherwise not susceptible. Most slopes in Western Oregon steeper than 30 degrees (~60%) have a risk of rapidly moving landslide activity regardless of geologic unit. Areas directly below these slopes in the paths of potential landslides are at risk as well.

Based on the Oregon Department of Forestry Storm Impacts Study, the highest debris flow hazard occurs in Western Lane County, Western Douglas County, and Coos County. The combination of steep slopes and geologic formation (sedimentary rock units) contributes to the increased hazard. The debris flow hazard is also high in much of the Coast Range and Cascade Mountains and in the Columbia River Gorge.

Deep landslides are generally defined as having a failure plane within the regional bedrock unit (generally greater than 15 feet deep), whereas the failure plane of shallow landslides is commonly between the thin soil mantle and the top of the bedrock. Deep landslide hazard is high in parts of the Coast Range. Deep landslides are fairly common in pyroclastic rock units of the Western Cascade Mountains, and in fine-grained sedimentary rock units of the Coast Range. Deep landslides also occur in semi-consolidated sedimentary rocks at or near the Oregon coast particularly around Newport, Lincoln County and Tillamook County, and in the Troutdale Formation around the Portland area.

Infrequent very large landslides and debris flows may occur in any of the larger mountain ranges or in deep gorges throughout Oregon.

During 1996 and 1997, heavier than normal rains caused over 700 landslides within the Portland Metropolitan region, which totaled over $40 million for mitigation (Burns et al., 1998). In the City of Portland, 17 homes were completely destroyed and 64 were badly damaged. There were no serious injuries associated with the landslides in Portland or in other urban areas within Oregon during the 1996 storms.

The Oregon Department of Forestry Storm Impacts Study estimated that tens of thousands of landslides occurred on steep slopes in the forests of Western Oregon during 1996. The Oregon Department of Geology and Mineral Industries Slope Failures in Oregon inventoried thousands of reports of landslides across the state resulting from the 1996-1997 storms. There are a significant number of locations in Oregon that are impacted frequently (every 10 to 100 years) by dangerous landslides. The number of injuries and deaths in the future will be directly related to vulnerability: the more people in these areas, the greater the risk of injury or death.

Burns, S.F., Burns, W.J., James, D.H., and Hinkle, J.C., 1998. Landslides in Portland, Oregon: Metropolitan Area Resulting from the Storm of February 1996: Inventory Map, Database, and Evaluation. METRO Natural Hazards Publication 905828, p.1-65.

Historic Landslides in Oregon

Oregon has declared 28 major disaster declarations from 1955-2012. Most of these are related to storm events causing flooding and landslides. One of the most significant of these disasters is the 1996 and 1997 storms which caused thousands of landslides in Oregon.

Table 2-LS-2: Historic Landslides in Oregon from SLIDO-2

Date	Count	Comments
1931-1935	2	
1946-1950	1	
1951-1955	2	
1956-1960	1	
1961-1965	14	Presidential DR184
1966-1970	1	
1971-1975	11	
1976-1980	24	
1981-1985	9	
1986-1990	8	
1991-195	42	
1996-2000	7,903	Presidential DR1099
2001-2005	648	Presidential DR1510
2006-2010	1,960	Presidential DR1824 & DR1956
Total	**10,626**	

Source: Burns, W.J., Mickelson, K.A., Saint-Pierre, E.C., 2011. Statewide Landslide Information Database of Oregon Release-2, Oregon Department of Geology and Mineral Industries, SLIDO-2

Burns, W.J., Mickelson, K.A., Jones, C.B., Pickner, S.G., Hughes, K.L., Sleeter, R., 2013. Landslide hazard and risk study of northwestern Clackamas County, Oregon: Oregon Department of Geology and Mineral Industries, Open-File Report O-13-08, 74 map plates

Probability

Landslides are found in every county in Oregon as shown in the Table 2-LS-1. There is a 100% probability of landslides occurring in Oregon in the future. Although we do not know exactly where and when they will occur, they are more likly to happen in the general areas where landslides have occurred in the past. Also, they will likely occur during heavy rainfall events or during a future earthquake.

In order to reduce losses from landslides, areas of landslide hazard must first be identified. The first step in landslide hazard identification is to create an inventory of past (historic and prehistoric) landslides. Once this inventory is created, it can be used to create susceptibility maps which display areas that are likely to have landslides in the future. Once the landslide hazards are identified on inventory and susceptibility maps, the risk can be quantified, mitigation projects prioritized and implemented.

In 2005, DOGAMI began a collaborative landslide research program with the U.S. Geological Survey (USGS) Landslide Hazards Program to identify and understand landslides in Oregon. In order to begin the extensive undertaking of mapping existing landslides throughout Oregon, a pilot project area was selected to compare remote sensing data/images for effectiveness. The remote sensing data sets compared included (Burns, 2007): (Figure 2-LS-3)

1. 30 m (98 ft) Digital elevation model (DEM) from the Shuttle Radar Topography Mission
2. 10 m (33 ft) DEM derived from the USGS topographic quadrangles
3. Photogrammatic and ground based 1.5 m (5 ft) interval contour data
4. Stereo aerial photographs from 1936 to 2000
5. Lidar imagery with an average of 1 data point per m^2 (3.2 ft) and with a vertical accuracy of about 5 cm (6 in)

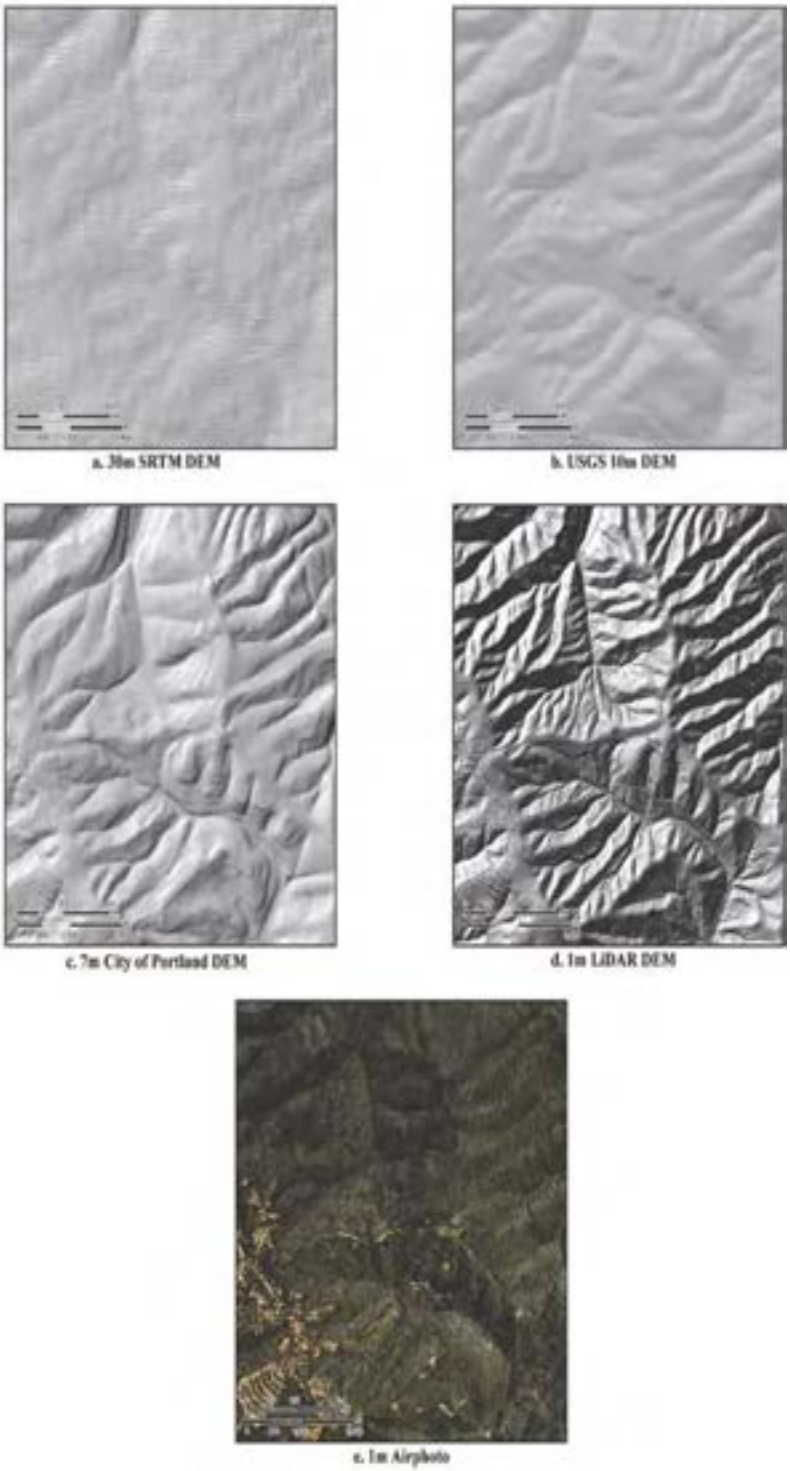

Figure 2-LS-3: Visual comparison of the five (a, b, c, d, e) remote sensing data sets. The air photo is draped over a DEM so that it appears to have the 3-dimensional view provided by a stereo-pair.

Two key findings of the pilot project were: 1) the use of the LIDAR data resulted in the identification of between 3 to 200 times the number of landslides identified using the other data sets and 2) the ease and accuracy of mapping the spatial extent of the landslides identified from lidar data were greatly improved compared to other mapping methods.

When examining the results of the comparison of remote sensing data, several debris flow fans at the mouths of channels or potential channelized debris flow deposits, were identified with serial stereo-pair aerial photos, which did not get identified on the lidar derived DEMs. Dense development has taken place in Oregon in the last 40 years, which can mask landslide features, especially if major earthwork has taken place. In most of the populated areas of Oregon, if historic air photos are available, at least one review of (greater than 40 years old) photos should be performed (Burns, 2007).

In order to develop accurate large scale landslide inventory maps, DOGAMI recommends the following minimal requirements:

1. All previously identified landslides from geologic maps, previous landslide studies, and other local sources should be compiled.

2. The mapper should have experience identifying all types and ages of landslides within the area being studied.

3. Lidar data should be used to identify landslides and accurately locate the extents of previously mapped landslides (from step 1).

4. An orthophoto of similar age to the LIDAR data should be used to minimize the misidentification of man-made cuts and fills as landslides.

5. The mapper should use at least one set of historical stereo-pair aerial photography to locate landslides in the area being studied.

6. Non-spatial data should also be collected at the time of the mapping so that a comprehensive database can be formed. Non-spatial data should generally include confidence of interpretation, movement class, direction of movement, etc. and are described in detail in section 6.0 of this paper.A comprehensive check of spatial (map) and non-spatial data should be developed and implemented including technical review of mapped landslides and field checks where possible.

Step one was accomplished in 2008 with the publication of SLIDO-1. This publication has been updated and again published as SLIDO-2 (Figure 2-LS-4).

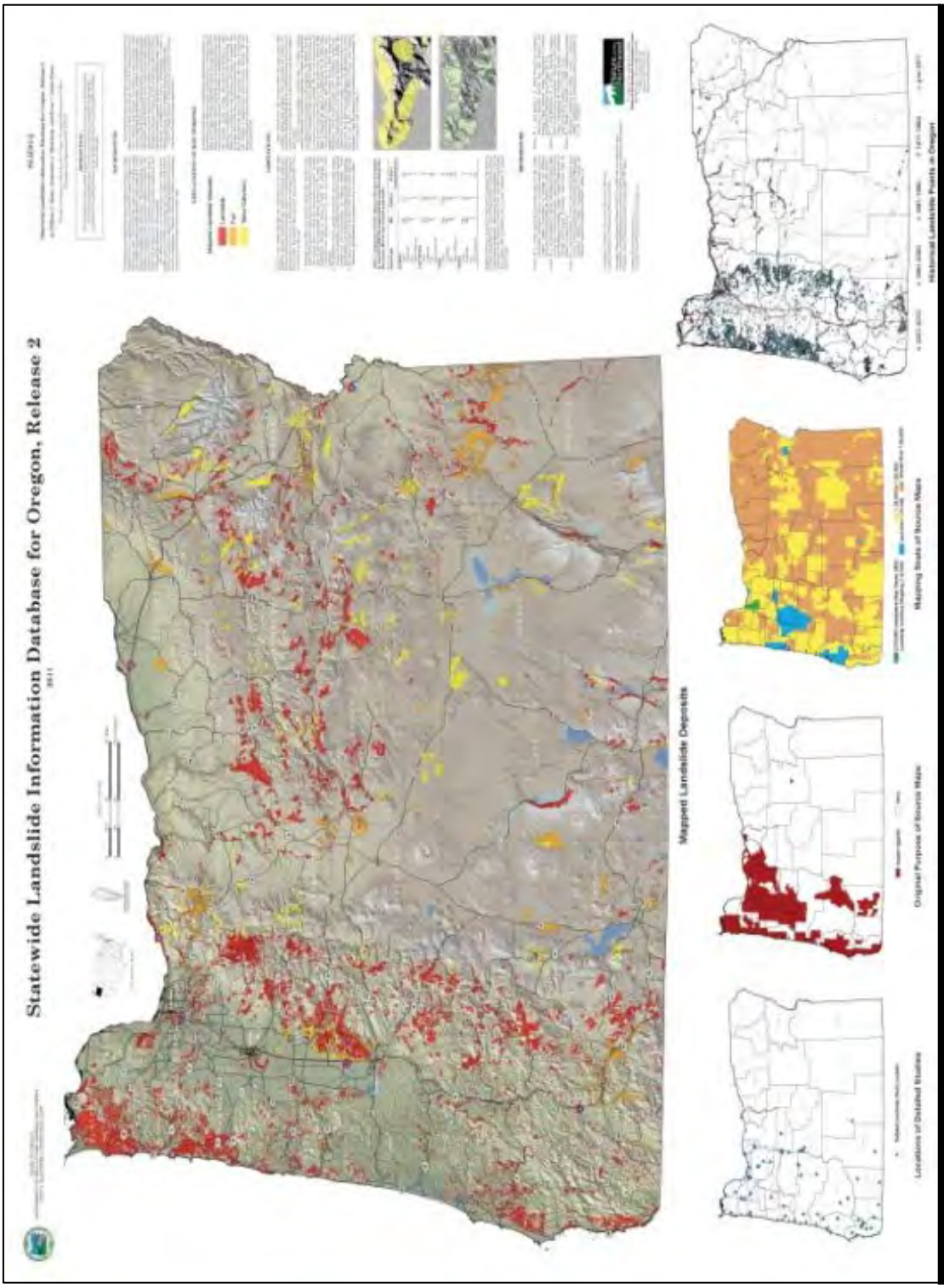

Figure 2-LS-4: Statewide Landslide Information Database for Oregon, Release 2. The resulting SLIDO-2 geodatabase includes 22,542 landslide deposit polygons and landslide-related features from 313 published and unpublished studies, 10,636 historical landslide point locations (including all points from the 1996-97 events), and 72 locations of detailed studies on individual landslides, a significant increase over SLIDO-1.

Source: DOGAMI

A protocol was developed by DOGAMI so that we can produce consistent lidar-based landslide inventory maps at an accelerated rate without having to describe how the mapping was done every time a new area is mapped (Burns and Madin, 2009). The results of following this protocol in any particular area include a very detailed database and map of the landslide inventory (Figure 2-LS-5).

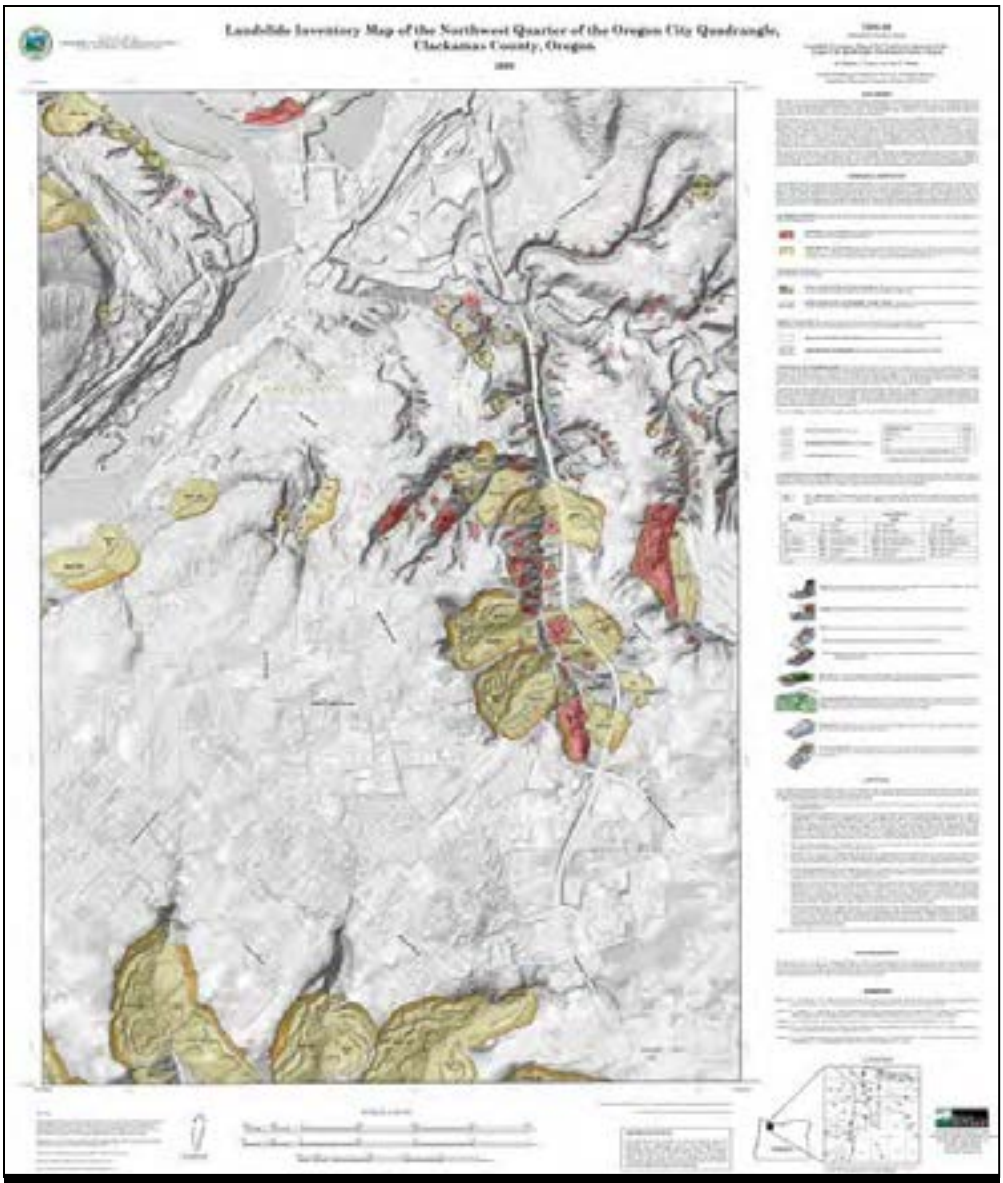

Figure 2-LS-5: Example of a new Lidar-based landslide inventory (Oregon City,OR)

Source: DOGAMI

Burns, W. J., 2007, Comparison of remote sensing datasets for the establishment of a landslide mapping protocol in Oregon. AEG Special Publication 23: Vail, Colo., Conference Presentations, 1st North American Landslide Conference.

Burns, W.J., Madin, I.P., 2009. Protocol for Inventory Mapping of Landslide Deposits from Light Detection and Ranging (lidar) Imagery, Oregon Department of Geology and Mineral Industries, Special Paper 42

With an accurate landslide inventory in hand, the next step in a complete landslide hazard mapping program is to develop susceptibility maps for common types of landslides. DOGAMI has just finished a shallow landslide susceptibility method and is in progress of completing deep landslide and channelized debris flow susceptibility mapping protocols.

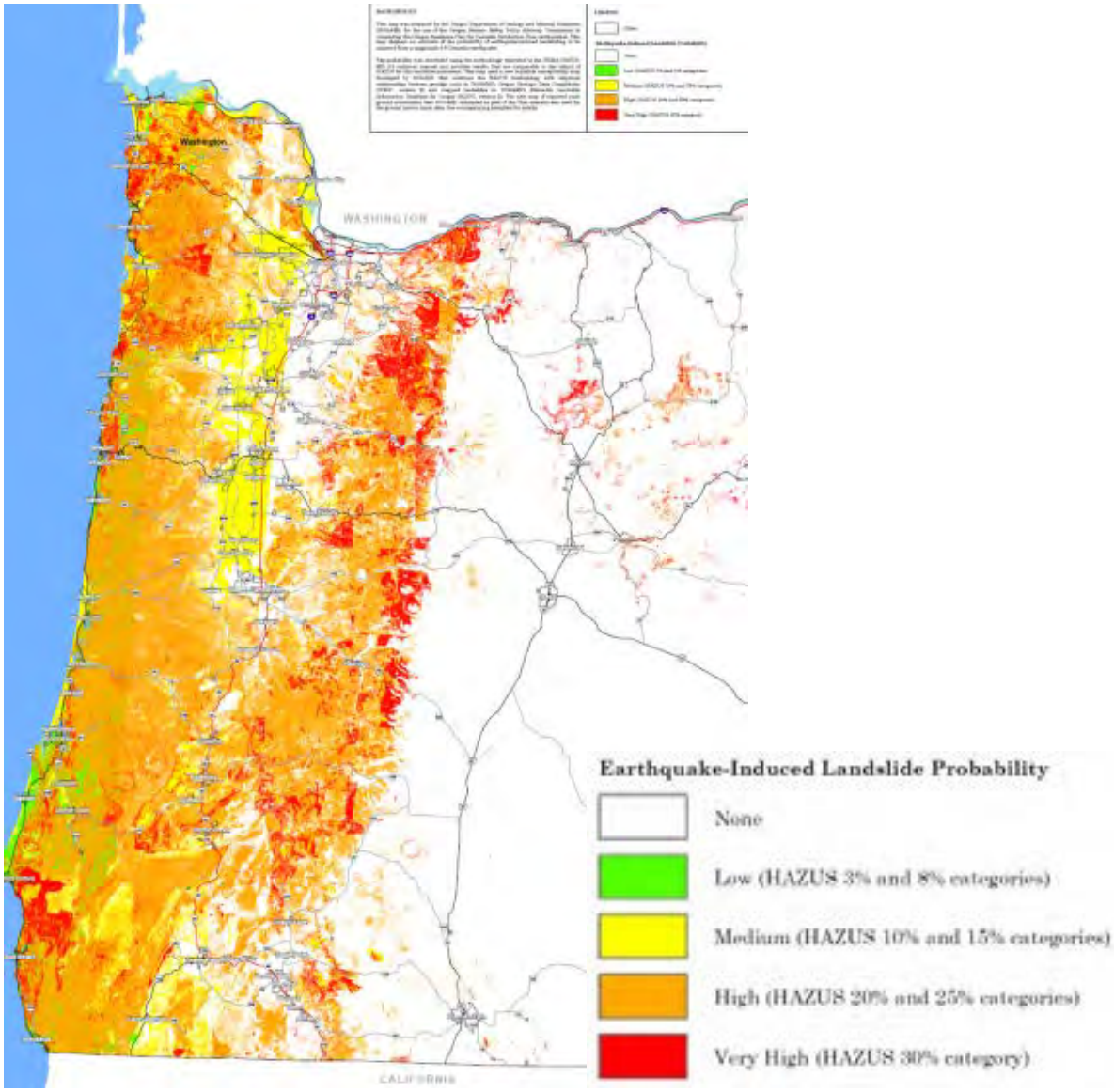

Figure 2-LS-6: Earthquake-Induced Landslide Probability

Source: Madin and Burns, 2013

Madin, I.P. and Burns, W.J., 2013. Ground motion, ground deformation, tsunami inundation, coseismic subsidence, and damage potential maps for the 2012 Oregon Resilience Plan for Cascadia Subduction Zone Earthquakes: Oregon Department of Geology and Mineral Industries, Open-File Report O-13-06.

Tsunami

What is a tsunami?

Tsunamis are a low frequency natural hazard in Oregon and are restricted almost exclusively to coastal areas. Tsunamis are most often caused by the abrupt change in the seafloor accompanying an earthquake (Figure 2-TS-1).The most common sources of the largest tsunamis are earthquakes that occur at subduction zones like the Cascadia Subduction Zone (CSZ), where an oceanic plate descends beneath a continental plate (Figure 2- TS-2). Other important processes that may trigger a tsunami include underwater volcanic eruptions and landslides (includes landslides that start below the water surface and landslides that enter a deep body of water from above the water surface). Tsunamis can travel thousands of miles across ocean basins, so that a particular coastal area may be susceptible to two different types of tsunami hazard caused by:

1) Distant sources across the ocean basin, and

2) Local sources that occur immediately adjacent to a coast.

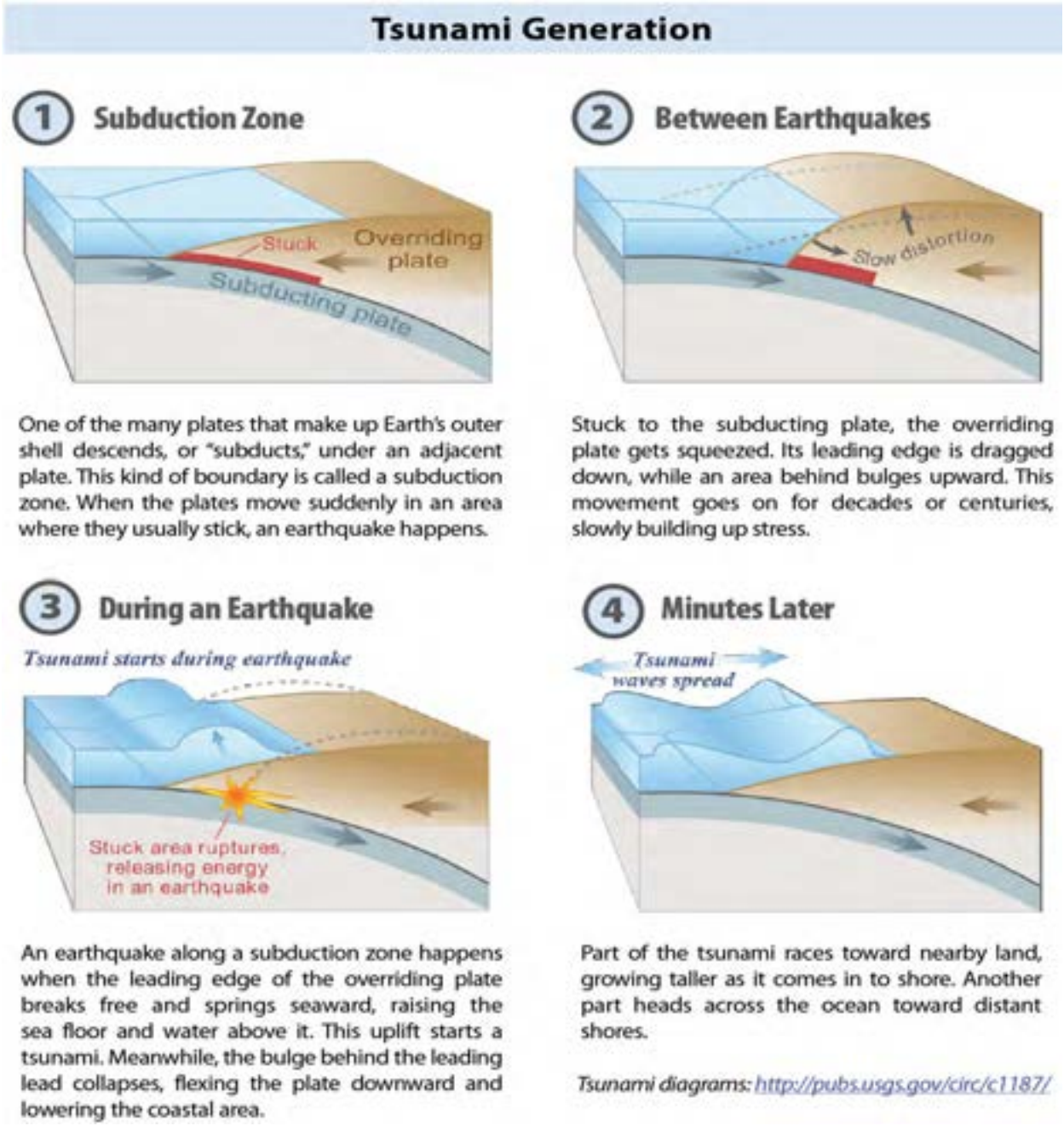

Figure 2-TS-1: Generation of a Tsunami by Subduction Zone Earthquakes

Source: DOGAMI Cascadia Winter 2012.

Figure 2-TS-2: Map of the surface trace of the Cascadia Subduction Zone (CSZ) active fault (triangles). The fault is the contact where the Juan de Fuca Plate plunges beneath the North American continental plate.

Source: DOGAMI

Distant tsunamis that may threaten the Oregon Coast are usually generated by a subduction zone earthquake elsewhere in the Pacific and would take at least 4 hours to reach the Oregon coastline from the closest source, the subduction zone in the Gulf of Alaska. For example, the 1964 Alaska tsunami reached the Oregon Coast in four to five hours after the magnitude 9.2 earthquake that generated it. In contrast, a local tsunami generated by a CSZ earthquake, would take about 15-20 minutes to reach most of the coast.

Most locally-generated tsunamis will be higher and travel farther inland (overland and up river) than distant tsunamis. By the time the tsunami wave hits the coastline, it may be traveling at 30 mph and have heights of 20 to ~100 feet, depending on the local coastal bathymetry (water depths), shape of the shore, and the amount of fault movement on the subduction zone. The tsunami wave will break up into a series of waves that will continue to strike the coast for a day or more, with the most destructive waves arriving in the first 4-5 hours after the local earthquake. As was seen in the 2004 Sumatra tsunami, the first wave to strike the coast is not always the most destructive. This was again the case during the 2011 Japan tsunami.

The coasts of Washington, Oregon, and northern California are particularly vulnerable to tsunamis from magnitude 9+ earthquakes that occur about every 500 years on the CSZ (Figure 2-TS-2). Additional, smaller tsunamis and earthquakes occur in the subduction zone south of Waldport. The combined recurrence for both types of Cascadia earthquake can be as low as ~230 years in Curry County.

The initial tsunami wave mimics the shape and size of the sea floor movement that causes it, but quickly evolves into a series of waves that travel away from the source of disturbance, reflect off of coastlines, and then return again and again over many hours. The tsunami is thus “trapped” owing to the processes of reflection and refraction. In the deep ocean, tsunami waves may be only a few feet high and can travel at wave speeds of 300 - 600 mph. As a tsunami approaches land where the water depth

decreases, the forward speed of the wave will slow as wave height increases dramatically. When the wave makes landfall, the water is mobilized into a surging mass that floods inland until it runs out of mass and energy. The wave then retreats, carrying all sorts of debris. Successive waves then batter the coast with this debris. Swimming through such turbulent debris-laden water is next to impossible.

Tsunamis are potentially more destructive than the earthquake that caused them. Loss of lives from the tsunami can often be many times the loss from the earthquake ground shaking. This was highlighted by the December 26, 2004 tsunami, associated with a magnitude 9.3 earthquake, which occurred offshore from the Indonesian island of Sumatra. The tsunami impacted almost every county located around the Indian Ocean rim and claimed the lives of approximately 350,000 people. The greatest loss of life occurred along the coast of Sumatra, close to the earthquake epicenter. The event displaced some 2 to 3 million people and its economic impact continues to be felt to the present. The Sumatra event is a direct analogue for what can be expected to occur along the Oregon Coast due to its close proximity to the Cascadia Subduction Zone.

In addition, fires started by the preceding earthquake are often spread by the tsunami waves, if there is a gasoline or oil spill. As was seen in the Sumatra 2004 tsunami, flood inundation from a tsunami may be extensive, as tsunamis can travel up rivers and streams that lead to the ocean. Delineating the inland extent of flooding, or inundation, is the first step in preparing for tsunamis.

Analysis and Characterization

The entire coastal zone is highly vulnerable to tsunami impact. Distant tsunamis caused by earthquakes on Pacific Rim strike the Oregon coast frequently but only a few of them have caused significant damage or loss of life. Local tsunamis caused by earthquakes on the Cascadia Subduction Zone (CSZ) happen much less frequently but will cause catastrophic damage and, without effective mitigation actions, great loss of life.

Figure 2-TS- 3: Tsunami damage on the Chetco River, Oregon from March 11, 2011 tsunami.

Source: USGC

On March 11, 2011, a magnitude (M_w) 9.0 earthquake struck off the east coast of Japan. This caused a massive tsunami that inundated much of the eastern coastline of Japan, and reached the west coast of the U.S. many hours later. There was one death and millions of dollars of damage to ports and harbors in Oregon and California (Figure 2-TS-3). Japan suffered many thousands of dead and missing as well as a nuclear catastrophe which will continue to be a hazard far into the future. Oregon received a Presidential Declaration of Disaster (DR-1964) which brought millions of dollars of financial aid to repair and mitigate future tsunami damage. Debris from tsunami-damaged buildings in Japan floated across the Pacific Ocean and began arriving on the Canadian and US West Coast in December 2011 and is expected to continue to arrive for years.

In March 1964, a tsunami struck southeastern Alaska following an earthquake beneath Prince William Sound and arrived along the Alaska coastline between 20 and 30 minutes after the quake, devastating villages. Damages were estimated to be over $100 million (1964 dollars). Approximately 120 people drowned. The tsunami spread across the Pacific Ocean and caused damage and fatalities in other coastal areas, including Oregon. The tsunami killed five people in Oregon and caused an estimated $750,000 to $1 million in damage. In Crescent City, California, there were 10 fatalities, while damage to property and infrastructure was estimated to range from $11 to 16 million.

Going still further back in time, there is scientific consensus that the Pacific Northwest experienced a subduction zone earthquake estimated at magnitude 9 on January 26, 1700. The earthquake generated a tsunami that caused death and damage as far away as Japan, where it was well-documented in the literature of the time. The earthquake and tsunami left behind geologic “footprints” in the form of (1) tsunami sand sheets in marshes, (2) layers of marsh vegetation covered by tide-borne mud when the coast abruptly subsided, and (3) submarine sand and silt slurries shaken off the continental shelf by the earthquake (turbidites). The widespread and large body of oral traditional history of the Thunderbird and Whale stories passed down by First Nations people depict both strong ground shaking and marine flooding that may have been inspired by this event. Although this earthquake undoubtedly produced tsunamis that reached on the order of 30-40 feet at the coast, geologic evidence from study of 10,000 years of turbidite deposits suggests that the 1700 earthquake was just an average event. Some Cascadia earthquakes have been many times larger, so, while devastating, the earthquake and tsunami were far from the worst case.

In 2010 the Oregon Department of Geology and Mineral Industries (DOGAMI) completed an analysis of the full range of Cascadia tsunamis and earthquakes, separating the results into 5 size classes with "T-shirt" names, S, M, L, XL, and XXL. The XL or XXL events probably only happened once or twice in the last 10,000 years, but estimated tsunami heights were comparable to those of the 2011 Japan and 2004 Sumatra tsunamis, the largest known.

The tsunami wave tends to arrive at the coast as a fast moving surge of rising water. As the tsunami enters coastal bays and rivers, it may move as a high velocity current or a breaking wave that travels up an estuary as a bore (wall of turbulent water like the waves at the coast after they break). This inland wave of water can often cause most or all of the damage, and the current may be just as destructive when it is retreating from the land as when it is advancing. For example, in Seaside the damage from the 1964 Alaskan tsunami occurred along the Necanicum River and Neawanna Creek, well inland from the coast. In addition, storm waves and wind waves may ride on top of the tsunami waves, further compounding the level of destruction.

During Cascadia earthquakes there is also the added effect of coastal subsidence, or the downward movement of the land relative to the sea level, during the earthquake. This is due to the release of the accumulated strain that caused the western edge of the North American Plate to bend and bulge. The new earthquake models used for the local tsunami scenarios indicate that portions of the Oregon coast could drop by a few to several feet.

Seven tsunami flooding (inundation) zones are mapped by DOGAMI: five Cascadia tsunami scenarios, S, M, L, XL, XXL, and two maximum-considered distant tsunami scenarios (the 1964 Alaska tsunami and a larger hypothetical maximum Alaska tsunami, AKmax). All 7 are depicted on DOGAMI tsunami inundation maps (TIM's, Figure T-4) plus digital files for use in geographic information systems (GIS). The 5 local CSZ-sourced inundation scenarios involve greater and greater amounts of movement on the subduction zone fault, ranging from 30 feet (S scenario) to 144 feet (XXL scenario).The 7 inundation lines are reduced to 2 for evacuation planning: AKmax inundation is the distant tsunami evacuation zone, and XXL is the local tsunami evacuation zone (Figure 2-TS-4). Brochures illustrating these zones and evacuation routes are available for all population centers, but both zones can also be viewed for any part of the coast using an interactive map portal and mobile phone apps at www.oregontsunami.org. The evacuation zones are critical for life safety planning and preparation. All seven scenarios assumed a maximum high tide (MHHW) tide and include the effects of subsidence from the earthquake fault process (release of strain on the North American Plate).

Figure 2-TS-4. Examples from North Bend (Coos Bay area) of DOGAMI tsunami inundation maps (TIM's in top two maps) and an evacuation map (bottom map). The top map illustrates inundation for five "T-shirt" size CSZ scenarios (S, M, L, XL, and XXL); the middle map shows inundation from two maximum considered distant tsunamis from subduction zone earthquakes in the Gulf of Alaska, a hypothetical maximum (termed Alaska Maximum or AKmax in DOGAMI databases), and the largest historical event that struck the Oregon coast in 1964 . Note the close similarity of Alaska Maximum to the Small CSZ inundation.

Source: DOGAMI. Visit: www.oregontsunami.org

Historical Tsunami Events in Oregon

Table 2-TS-1 lists historic tsunami events in Oregon.

Table 2-TS-1: Historic Tsunamis in Oregon

Date	Origin of Event	Affected Oregon Community	Damage	Remarks
04/1868	Hawaii	Astoria		Observed
08/1868	N. Chile	Astoria		Observed
08/1872	Aleutian Is	Astoria		Observed
11/1873	N. California	Port Orford		Debris at high tide line
04/1946	Aleutian Is	Bandon		Barely perceptible
04/1946		Clatsop Spit		Water 3.7m above MLLW
04/1946		Depoe Bay		Bay drained. Water returned as a wall
04/1946		Seaside		Wall of water swept up Necanicum River
11/1952	Kamchatka	Astoria		Observed
11/1952		Bandon	Log decks broke loose	
05/1960	S. Cent. Chile	Astoria		Observed
05/1960		Seaside	Bore on Necanicum River damaged boat docks	
05/1960		Gold Beach		Observed
05/1960		Newport		Observed for about four hours
05/1960		Netarts	Some damage observed	
03/1964	Gulf of Alaska	Cannon Beach	Bridge and motel unit moved inland. $230,000 damage	
03/1964		Coos Bay	$20,000 damage	
03/1964		Depoe Bay	$5,000 damage; 4 children drowned at Beverly Beach	
03/1964		Florence	$50,000 damage	
03/1964		Gold Beach	$30,000 damage	
03/1964		Seaside	1 fatality (heart attack); Damage to city: $41,000; Private: $235,000; Four trailers, 10-12 houses, two bridges damaged	
05/1968	Japan	Newport		Observed
04/1992	N. California	Port Orford		Observed
10/1994	Japan	Coast		Tsunami warning issued, but no tsunami observed
3/2011	Japan	Coast	$6.7 million. Extensive damage to the Port of Brookings.	Tsunami warning issued, observed ocean waves. and

Source: NOAA, 1993, Tsunamis Affecting the West Coast of the United States: 1806-1992.
FEMA, 2011, Federal Disaster Declaration

In addition to the historical distant tsunamis of Table 2-TS-1, the last CSZ tsunami struck at 9 PM on January 26, 1700. This may be considered a historical event, because the tsunami was recorded in historical port records in Japan. The date and time of occurrence here in Oregon were inferred by Japenese and USGS researchers from a tsunami and earthquake model.

Probability

While large (~magnitude 9) CSZ earthquakes and associated tsunamis have occurred on average every ~500 years over the last 10,000 years, the time interval between events has been as short as decades and as long as 1150 years. Smaller earthquakes on the southern part of the CSZ have occurred about as often as larger earthquakes, making CSZ events in southernmost Oregon about twice as likely as in northern Oregon. The size and frequency of the 19 large earthquakes on the CSZ are inferred from offshore turbidite deposits and are shown in Figure 2-TS-5. All 19 of these large CSZ events were likely magnitude 8.7 to 9.2 earthquakes.

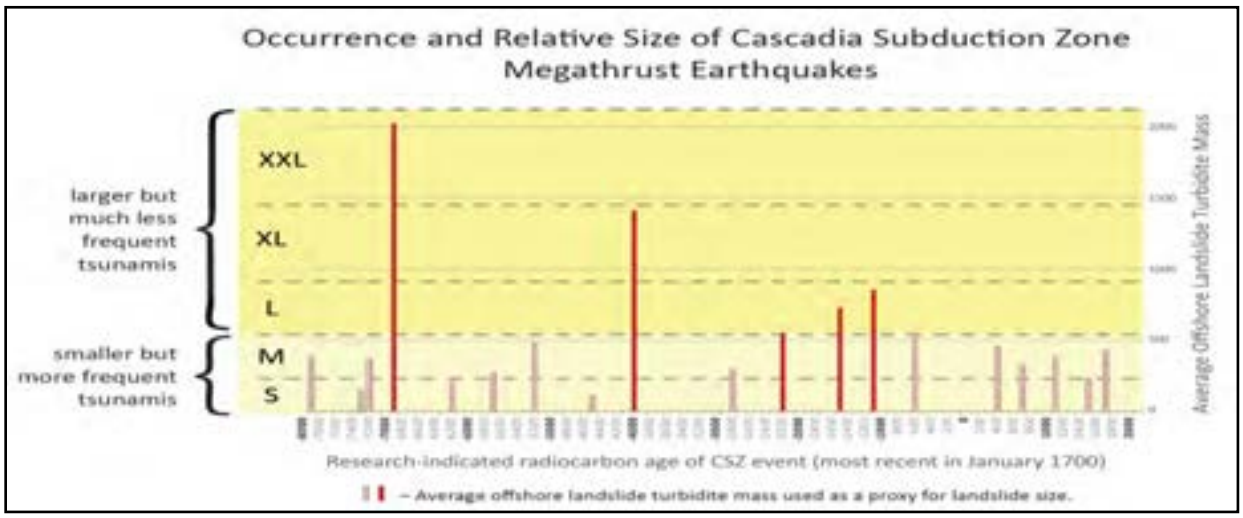

Figure 2-TS-5: Occurrence and Relative Size of Cascadia Subduction Zone Megathrust Earthquakes

Source: DOGAMI Cascadia, Winter 2012

In April 2008 the USGS wrote that for the next 30 years there is a 10% probability of a magnitude 8 to 9 quake somewhere along the 750-mile-long Cascadia Subduction Zone. In 2012 USGS Professional Paper 1661-F (http://pubs.usgs.gov/pp/pp1661f/) showed that the southern part of the CSZ also ruptures in segments, so probabilities some type of CSZ earthquake increase from north to south, as illustrated in Figure 2-TS-6. Segment earthquakes and tsunamis will generally be smaller than full-margin events. Segment tsunamis, by the time they travel more than ~43 miles north of a segment, are similar in size to distant tsunamis with the largest waves striking 2 hours or more after the earthquake (Priest et al., 2014; http://link.springer.com/article/10.1007/s11069-014-1041-7). New tsunami inundation maps from DOGAMI illustrate the range of inundation from all full-margin and significant segment ruptures on the CSZ.

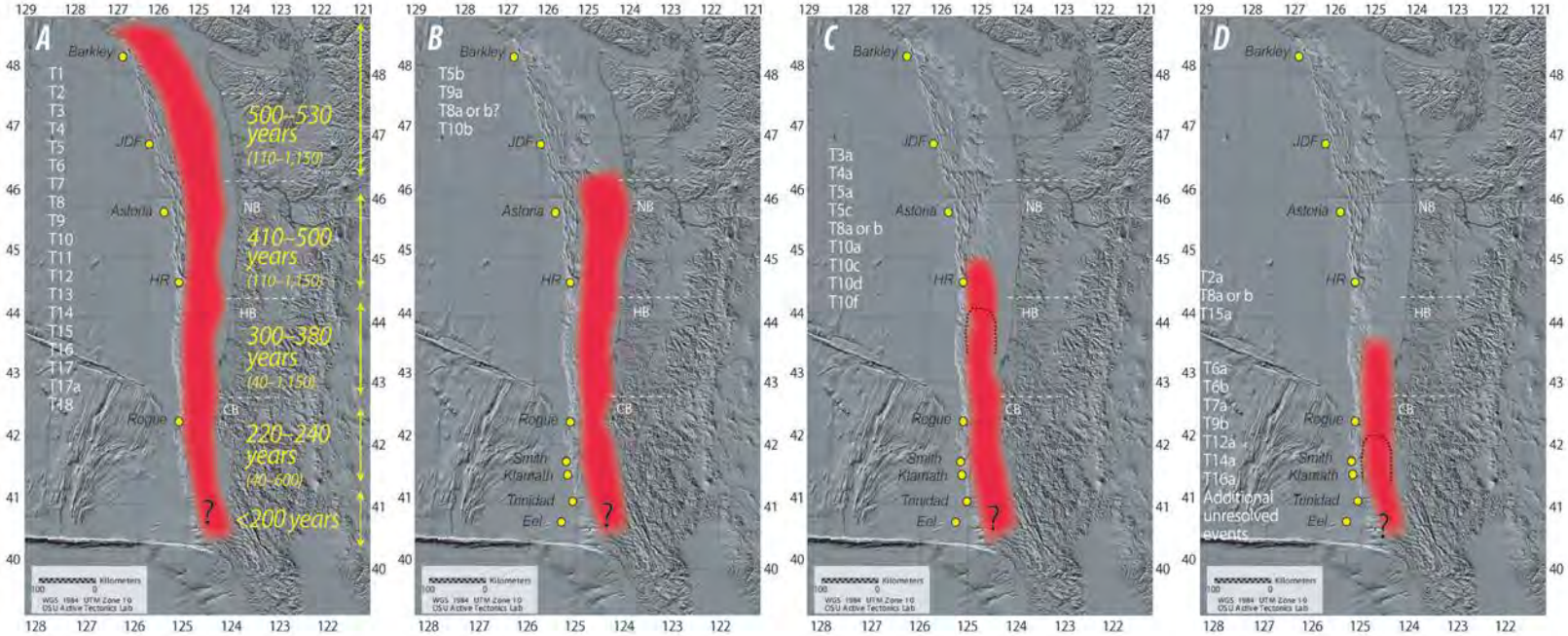

Figure 2-TS-6. Red areas depict hypothetical rupture patches of Cascadia subduction zone (CSZ) earthquakes over the last ~10,000 years inferred by Goldfinger et al. (2012) from marine and onshore paleoseismic data plus geological and geophysical data. White line with triangles marks the CSZ deformation front also visible as boundary between smooth to rough terrain. Numbers with "T" prefixes are offshore turbidite layers correlated with each rupture patch and arranged with youngest at the top. The white dashed lines are inferred segment boundaries of CSZ ruptures designated segments A (full-margin rupture), B (rupture north to Nehalem Bank (NB)), C (rupture north to Heceta Bank (HB)), and D (rupture north to Coquille Bank (CB)). Northern extents of segment D events break into two groups, one terminating south of the Rogue submarine canyon, indicated by dashed line. The second group extends north of Rogue but is not observed at Hydrate Ridge (HR). Although presumed to extend no further south than the southern terminous of the CSZ at Cape Mendocino, southern rupture limits are poorly known for all events indicated by query, limited by temporal coverage of turbidites and probable non-seismic turbidites in the early Holocene. Uncertainty in the northern extent of segments C and D are shown as the difference between the red patches and the black dashed lines. In the map of segment A, mean return in years of CSZ earthquakes is listed at each latitude and is calculated by dividing the number of turbidite layers into 10,000 years; minimum and maximum time intervals between turbidites at each latitude is given in parentheses. See Priest et al. (2014; http://link.springer.com/article/10.1007/s11069-014-1041-7) for estimates of height and arrival times of Segment C and D tsunamis.

Source: Goldfinger et al. (2012).[1]

Volcano

Volcanoes are potentially destructive natural phenomena, constructed as magma ascends and then erupts onto the earth's surface. Volcanic eruptions are typically focused around a single vent area, but vary widely in explosivity. Therefore volcanic hazards can have far reaching consequences. Volcanic hazards may occur during eruptive episodes or in the periods between eruptions. Eruptive events may include hazards such as, pyroclastic surges and flows, ash fall, lava flows, or slurries of muddy debris and water known as lahars. Eruptions may last days to weeks or years, and have the potential to dramatically alter the landscape for decades. Unlike other geologic hazards (e.g., earthquakes, tsunamis), impending eruptions are often foreshadowed by a number of precursors including ground movements, earthquakes, and changes in heat output and volcanic gases. Scientists use these clues to recognize a restless volcano and to prepare for events that may follow. Hazards occurring between eruptive periods are typically related to earthquakes or natural erosion, which may trigger debris avalanches or debris flows on the flanks of the volcano. Such events often occur without warning.

Potentially hazardous volcanoes in Oregon are present along the crest of the Cascade Range and to a much lesser extent in the High Lava Plains. The volcanoes within these regions provide some of Oregon's most spectacular scenery and popular recreational areas, yet the processes that led to their formation also present significant challenges and hazard to communities within the region. The catastrophic eruption of Washington's Mount St. Helens in 1980 and subsequent activity demonstrate both the power and detrimental consequences that Cascade-type volcanoes can have on the region. Lessons learned at Mount St. Helens, led the U.S. Geological Survey (USGS) to establish the Cascades Volcano Observatory (CVO) in Vancouver, Washington. Scientists at CVO continually monitor volcanic activity within the Cascade Range and in cooperation with the Oregon Department of Geology and Mineral Industries (DOGAMI), study the geology of volcanic terrains in Oregon.

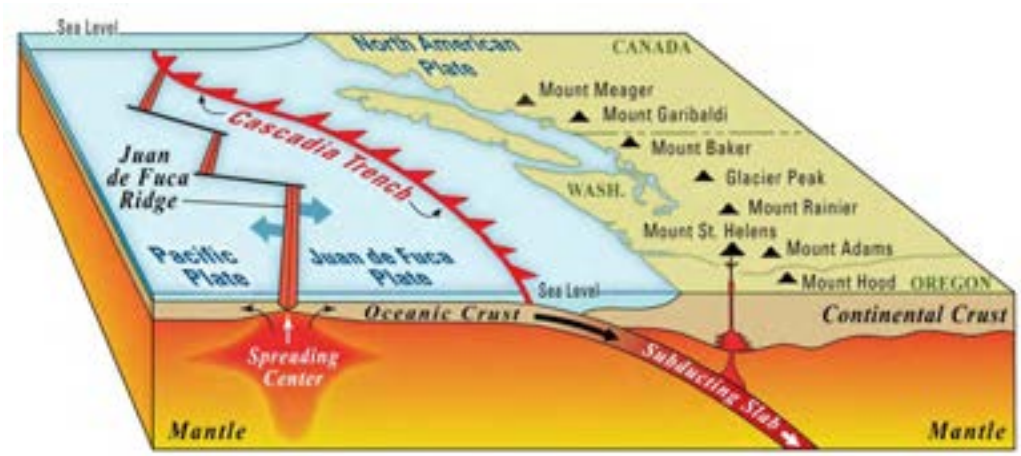

Figure 2-V-1: Cartoon diagram showing a generalized subduction zone setting.

Source: U.S. Geological Survey, Cascades Volcano Observatory
http://volcanoes.usgs.gov/vsc/multimedia/cvo_popular_graphics_gallery.html

Analysis and Characterization

The volcanic Cascade Range extends southward from British Columbia into northern California. The volcanoes are a result of the complex interaction of tectonic plates along the Cascadia Subduction Zone (CSZ). Subduction is the process that results in the Juan de Fuca plate (oceanic crust) subducting, or sinking, underneath the North American plate (continental crust) on which we live (Figure 2-V-1). As the subducted plate descends, it heats up and begins to melt. This provides the reservoir of heat and molten rock needed to create the magma chambers that lie kilometers deep, beneath the Cascades.

Stratovolcanoes like Mount Hood, also called composite volcanoes, are generally tall, steep, conical shaped features, built up through layering of volcanic debris, lava, and ash. Eruptions tend be explosive, for example, the violent 1980 eruption of Mount St. Helens, and they produce volcanic mudflows (lahars) that can travel far from the mountain. Future eruptions are likely to be similar and present a severe hazard to the surrounding area. Volcanoes also pose other hazards because of their geology and resulting geomorphology. The relatively high elevation of volcanoes usually results in the meteorological effect called orographic lifting, which causes high precipitation and snow on the mountains that can result in flooding. The geologic material tends to be relatively weak and, when combined with the steep slopes, can cause frequent and hazardous landslides. Cascade Mountain Range volcanoes are also located near the active CSZ and nearby potentially active crustal faults, which contribute to moderate seismic hazard in the area.

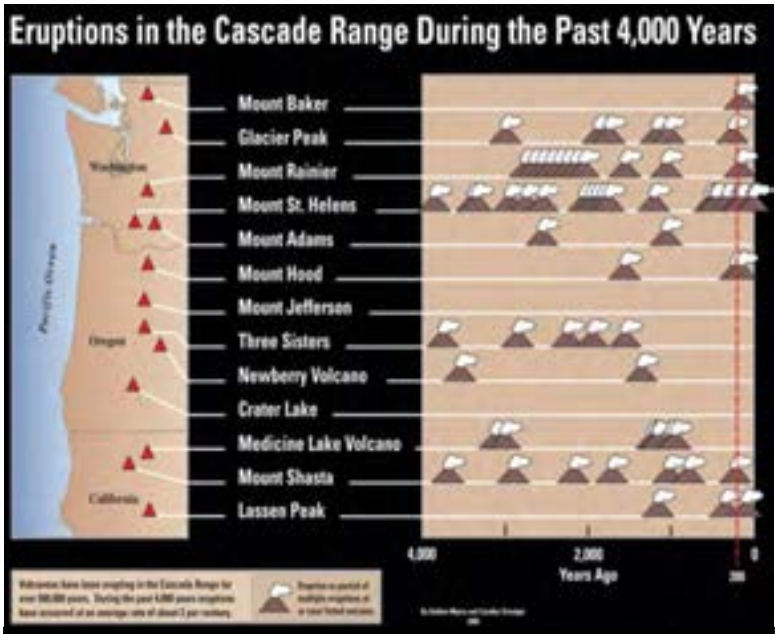

Figure 2-V-2: Eruptions in the Cascade Range during the Past 4,000 years.

Source: Myers and Driedger, (2008), USGS GIP-63

The volcanoes of the Cascade Range have a long history of eruption and intermittent quiescence. Note that in Figure 2-V-2, each volcano has a different frequency of eruption. Not all Cascade volcanoes have been active in the recent past. This is typical of a volcanic range and is one of the reasons forecasting eruptions can be difficult.

Several smaller volcanoes, including Diamond Craters and Jordan Craters, in the High Lava Plains of southeast Oregon have experienced eruptions in the last 6,000 years. Generally non-explosive eruptions at these sites have built complexes of lava flow fields and cinder cones. Unlike the far-reaching effects that may be generated by large, potentially explosive stratovolcanoes in the Cascade Range, hazards associated with future eruptions in sparsely populated southeast Oregon are most likely limited to localized lava flows.

Volcano-Associated Hazards

A number of hazards are associated with volcanoes (Figure V-3). In general, volcanic hazards are commonly divided into those that occur in proximal (near the volcano) and distal (far from the volcano) hazard zones. In the distal hazard zone, volcanic activity includes lahars (volcanic mudflows or debris flows) and fallout of ash; in the proximal hazard zone, activity can be much more devastating and includes rapidly moving pyroclastic flows (glowing avalanches), lava flows, and landslides. Each eruption is a unique combination of hazards. Not all hazards will be present in all eruptions, and the degree of damage will vary. It is important to know that during an active period for a volcano many individual eruptions may occur and each eruption can vary in intensity and length. For example, while Mount St. Helens is best known for its catastrophic May 1980 eruption, periodic eruptions of steam and ash and the growth of a central lava dome have continued to pose a hazard since that time.

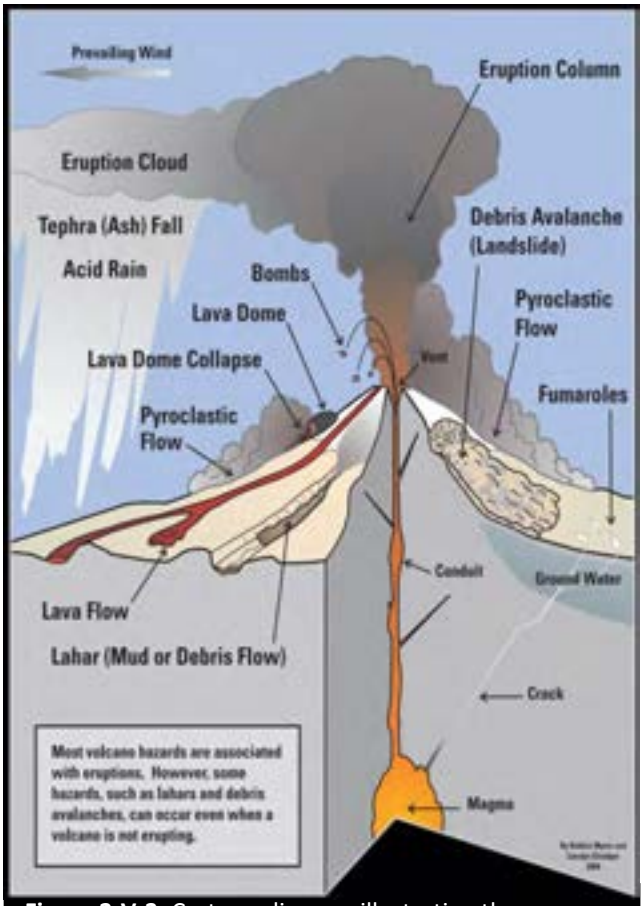

Figure 2-V-3: Cartoon diagram illustrating the potential hazards at a stratovolcanoe.

Source: Myers and Others 1997,

Eruptive hazard

Ash Fall

Dust-sized ash particles are the by-products of many volcanic eruptions. Ash, when blown into the air, can travel large distances causing significant problems for distal hazard zones. During ash-dominated eruptions, deposition is largely controlled by the prevailing wind direction. The predominant wind pattern over the Cascade Range is from the west to the east. Previous eruptions documented in the geologic record indicate most ash fall drifting to and settling in areas to the east of the Cascade volcanoes. The probable geographic extent of volcanic ash fall from select volcanic eruptions in the Pacific Northwest is depicted in the figure below (Figure 2-V-4).

Within a few miles of the vent, the main ash fall hazards to man-made structures and humans include high temperatures, being buried, and being hit by falling fragments. Within ten to twelve miles, hot ash fall may set fire to forests and flammable structures.

Structural damage can also result from the weight of ash, especially if it is wet. Four inches of wet ash may cause buildings to collapse. Accumulations of a half inch of ash can impede the movement of most vehicles, disrupt transportation, communication, and utility systems, and cause problems for human and animal respiratory systems. It is extremely dangerous for aircraft, particularly jet planes, as volcanic ash accelerates wear to critical engine components, can coat exposed electrical components, and erodes exposed structure. Ash fall may severely

decrease visibility, even cause darkness, which can further disrupt transportation and other systems. Recent work by the Volcano Hazards Group of the U.S. Geological Survey has attempted to rank the relative hazard of volcanoes in North America. According to this study, Oregon has four Very High Threat Volcanoes: Crater Lake, Mount Hood, Newberry Volcano, and South Sister (Ewert and others, 2005).

Ash fall can severely degrade air quality and trigger health problems. In areas with considerable ash fall, people with breathing problems might need additional services from doctors or emergency rooms. In severe events an air quality warning could be issued, informing people with breathing problems to remain inside

Ash fall can create serious traffic problems as well as road damage. Vehicles moving over even a thin coating of ash can cause clouds of ash to swell. This results in visibility problems for other drivers, and may force road closures. Extremely wet ash creates slippery and hazardous road conditions. Ash filling roadside ditches and culverts can prevent proper drainage and cause shoulder erosion and road damage. Blocked drainages can also trigger debris flows if the blockage causes water to pool on or above susceptible slopes. Removal of ash is extremely difficult as traditional methods, such as snow removal equipment, stir up ash and cause it to continually resettle on the roadway.

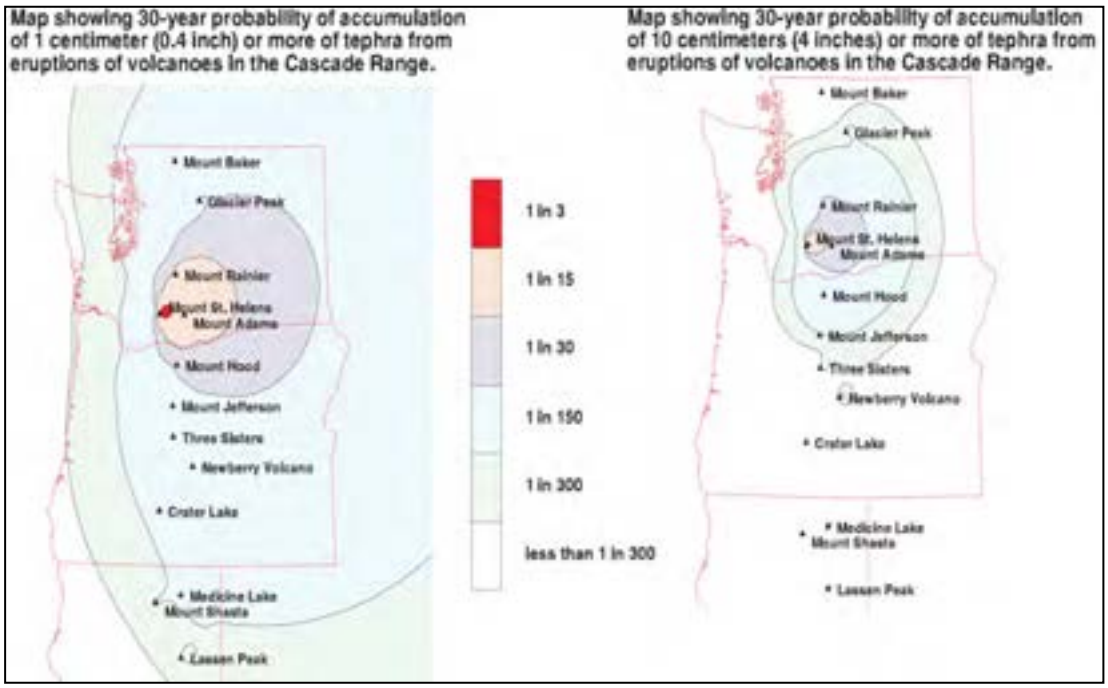

Figure 2-V-4: The probable geographic extent of volcanic ash fall from select volcanic eruptions in the Pacific Northwest.

Source: Scott and others, 1997.

Lahars

Cascade Range volcanoes and the floodplains that drain them contain abundant evidence for past lahar events. Lahars or volcanic debris flows are water-saturated mixtures of soil and rock fragments originating from a volcano. These sediment gravity flows can travel very long distances (over 62 mi) and travel as fast as 50 mi per hour in steep channels close to a volcano; further downstream, where they reach gently sloping valley flows speeds generally slow to 10 to 20 mi per hour. The largest of these flows are known to transport boulders exceeding 30 ft in diameter. Lahars are often associated with eruptions, but they can also be generated by rapid erosion of loose rock during heavy rains or by sudden outbursts of glacial water. Highly erodible, unconsolidated lahar deposits may be easily remobilized by normal rainfall, snowmelt, and streams for years after their deposition.

Figure 2-V-5: Trees buried in volcanic sediment, Sandy River, Oregon. Trunks of forest trees, initially growing on a terrace above the Sandy River (Oregon) at Oxbow Regional Park, were buried by rapid deposition of sediment following a dome-building eruption at Mount Hood in 1781. Erosion during a flood about a week before the photo was taken exposed this "ghost forest."

Photo Source: T.C. Pierson, USGS, 1/15/2009

Hazards associated with lahars include direct impact and burial by the advancing flow, burial of valuable infrastructure or agricultural land, and secondary flooding due to temporary damming and breakouts along tributary streams (Figure 2-V-5). Because of their relatively high viscosity, lahars can move, or even carry away, vehicles and other large objects such as bridges. Municipalities, industries, and individuals who take their water from streams affected by lahars may have water quality and/or quantity issues. Wildlife could be adversely affected by changes in streams, including the deposition of debris in streambeds and floodplains. For example, salmonids trying to spawn could find it impossible to swim upstream. Long-term drainage pattern alteration and increased sedimentation rates downstream may persist for decades following such an event.

Lava Flow

Lava flows are streams of molten rock that erupt relatively non-explosively from a volcano and move downslope. Hazards associated with lava flow events include ash falls proximal to vents, extensive damage or total destruction of objects in the lava flow path(s) by burning, crushing, or burial, and disruption of local stream drainages. Lava flows are generally not life threatening because people can usually out-walk or out-run them. The Parkdale Lava Flow, located along the north flank of Mount Hood, erupted from a small vent about 7,600 years ago (Figure V-6).

Figure 2-V-6: Oblique air-view of the Parkdale lava flow. The flow erupted around 7,600 years ago from a small vent located about 6 miles south of Parkdale, Oregon.

Photo source: Bill Burns, DOGAMI

Pyroclastic Flow and Surges

Pyroclastic flows are avalanches of rock and gas at temperatures of 600 to 1500 degrees Fahrenheit. They typically sweep down the flanks of volcanoes at speeds of up to 150 miles per hour. Pyroclastic surges are a more dilute mixture of gas and rock. They can move even more rapidly than a pyroclastic flow and are more mobile. Both generally follow valleys, but surges especially may have enough momentum to overtop hills or ridges in their paths. Because of their high speed, pyroclastic flows and surges are difficult or impossible to escape. If it is expected that they will occur, evacuation orders should be issued as soon as possible for the hazardous areas. Objects and structures in the path of a pyroclastic flow are generally destroyed or swept away by the impact of debris or by accompanying hurricane-force winds. Wood and other combustible materials are commonly burned. People and animals may also be burned or killed by inhaling hot ash and gases. The deposit that results from pyroclastic flows is composed of a combination of ash, pumice, and rock fragments. These deposits may accumulate to hundreds of feet thick and can harden to a resistant rock called tuff. Pyroclastic flows and surges are considered a proximal hazard, but in some instances may extend tens or even hundreds of miles from the volcanic vent.

Landslides

Because the stratovolcanoes that form the Cascade Mountains are composed of layers of weak fragmented rock and lava, they are prone to landslides. Landslides range in size from small to massive summit or flank failures like the one in May 1980 at Mount St Helens (Figure 2-V-7). They may be triggered by volcanic activity or during times of excessive rainfall or snowmelt. Speeds of movement range from slow creep to more catastrophic failure. If enough water is incorporated into the material, the failure will become a lahar.

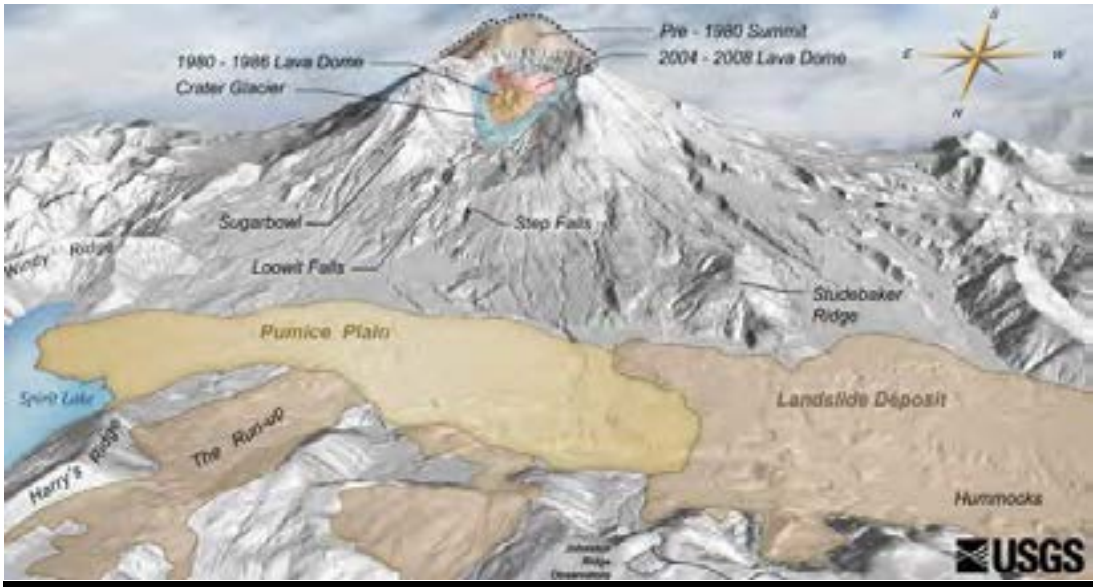

Figure 2-V-7: Mt. Saint Helens

Photo source: Bill Burns, DOGAMI

Non-Eruptive Hazards

Earthquake

Earthquake effects are a significant threat along the Cascade Mountains and come from three main sources: the CSZ, crustal faults, and volcanic activity. The CSZ is generally over 150 miles away, but it produces earthquakes as a large as M 9.0 every 240 to 500 years. Crustal earthquakes occur in the North American plate at relatively shallow depths of approximately 6 to12 miles below the surface. However, some can rupture through the surface. The distance from a potentially active fault is critical to the evaluation of the earthquake shaking hazard. Volcanic earthquakes are usually small and frequent, but they can be as large or larger than the M4.5 earthquake on Mount Hood in 2002. During 2002, a swarm of earthquakes ranging from M3.2 to M4.5 occurred on the southeast flank of Mount Hood. The damaging effects of all three kinds of earthquakes can be enhanced by amplification of shaking in soft soils, liquefaction, or induced landslides.

Flood and Channel Migration

The relatively high elevation of volcanoes usually results in the meteorological affect called orographic lifting, which causes high precipitation and snow on the mountains. The result can be very high levels of rainfall and/or rapid snowmelt that can result in flooding.

Floods cause damage to assets through inundation of water and by erosion and deposition of soil and/or large objects. Defining the hazard associated with inundation by flooding is done by calculating the area that is likely to be flooded during different levels of flooding. Larger floods are less frequent than smaller floods, so flood levels may be defined by their return period. The longer the return period, the deeper the flood waters, and hence the larger the area that is inundated. Some common return periods used in flood hazard mapping include 10-year, 25-year, 100-year, and 500-year floods. Most flooding on Cascade Range volcanoes occurs when heavy, warm rain during large winter or spring storms falls on accumulations of low-elevation snow. Channel migration hazards can occur slowly, for example, by continuous erosion along a cutbank meander and deposition onto a point bar during high flows, or very rapidly during storm events through avulsion or rapid abandonment of the current river channel for a new one. Such rapid migration can not only destroy structures but even remove the land beneath structures.

For more information on flooding and channel migration zones see the Flood section of this Plan, beginning on page 75.

Landslide

The general term landslide refers to a range of geologic events including rock falls, debris flows, earth slides, and other mass movements. Most landslides that occur on volcanoes are large deep-seated landslide complexes or debris flows. Deep-seated landslides have failure surfaces usually tens of feet below the surface and can cover large areas from acres to square miles. These types of landslides tend to move relatively slowly, but they can lurch forward if shaken by an earthquake or if disturbed by removal of material from the toe, by addition of material to the head, or by addition of water into the slide mass. Debris flows tend to initiate in the upper portions of a drainage, picking up water, sediment, and speed as they come down the drainage. As they reach the mouth of the confined/steep portion of the drainage, they tend to spread out and deposit the majority of the material, generally creating a fan. Debris flows are also commonly initiated by other types of landslides that occur on slopes near a channel. They can also initiate within the channel in areas of accelerated erosion during heavy rainfall or snowmelt.

Characterization of Individual Volcanoes

The history of volcanic activity in the Cascade Range is contained in its geologic record. The ages, eruptive history, and hazards associated with each volcano vary considerably. Cascade volcanoes may be characterized by intermittent periods of activity, followed by longer periods of relative quiescence. The incompleteness of eruptive records, even at relatively well-studied volcanoes, makes prediction of probability and recurrence intervals of future eruptions difficult to determine. Table 2-V-1 lists Cascade Volcanoes that reside in southwest Washington and Oregon that can affect Oregon communities. The discussion that follows, further details those volcanic centers from Table 2-V-1, that the U.S. Geological Survey has developed hazard assessments for and have ranked as having a high to very high threat potential. From north to south these high-threat volcanoes include: Mount St. Helens (Wolfe and Pierson, 1995), Mount Adams (Scott and others, 1995),Mount Hood (Scott and others, 1997; Burns and others, 2011), Mount Jefferson (Walder and others , 2000), the Three Sisters Region (Scott and others, 2001), Newberry Volcano (Sherrod and others, 1997), and Crater Lake (Bacon and others, 1997). Digital hazard data for some of these volcanoes has been produced by Schilling (1996); Schilling and others (1997), Schilling and others (2008a,b, c). For a detailed inventory of each volcano's history and hazards, please refer to the appropriate report referenced above, in Table V-1, and listed in Appendix X. Further information can also be obtained from the U.S. Geological Survey Cascade Volcano Observatory via the world-wide web at http://volcanoes.usgs.gov/observatories/cvo/.

Table 2-V-1: Prominent Volcanoes in the Cascade Range of Oregon and Southwest Washington

Volcano Name	Eleva-tion	Volcano Type	Most Recent Eruptions	USGS Threat Potential	Nearby Towns	Remarks/ Hazard Study
Mount St. Helens (WA)	8363 ft.	Stratovol-cano	1980-1986; 2004-2008	High to very high	Portland (OR); Castle Rock (WA); Olympia (WA); Vancouver (WA); Yakima (WA)	Major explosive eruption and debris avalanche in 1980. Widespread ash fall. Wolfe and Pierson (1995).
Mount Adams (WA)	12,277 ft.	Stratovol-cano	~520,000 to 1000 YBP;	High to very high	Portland (OR); Hood River (OR); Vancouver (WA); Yakima (WA)	Numerous eruptions in last 15,000 years. Major debris avalanches effecting White Salmon River at 6000 and 300 YBP. Scott and others (1995).
Mount Hood	11,240 ft.	Stratovol-cano	1760-1865	High to very high	Portland (OR); Sandy (OR); Welches(OR); Brightwood	Pyroclastic flows in the Upper White River drainage; lahars in Old Maid

					(OR); Parkdale (OR) Hood River (OR)	Flat; lava dome at Crater Rock; steam explosions. Scott and others (1997); Schilling and others (2008a).
Mount Jefferson	10,495 ft.	Stratovol-cano	280,000 to 15,000 YBP	Low to very low	Idanha (OR); Detroit (OR); Warm Springs (OR); Madras (OR); Lake Billy Chinook	Potentially active and capable of large explosive eruptions. Recent history of lava domes, small shields, and lava aprons.Walder and others (1999); Schilling and others (2007).
Mount Washington	7,796 ft.	Mafic volcano		Low to very low		No hazard study.
North Sister	10,085 ft.	Mafic volcano	300,000-120,000 YBP	High to very high	Sisters (OR); Bend (OR); Redmond (OR); Sunriver (OR); La Pine (OR); Blue River (OR); McKenzie Bridge (OR); Vida (OR); Springfield (OR)	Deep glacial erosion; Ash fall, pyroclastic flows, lava flows and domes, and lahars. Scott and others (2001); Schilling and others (2008c).
Middle Sister	10,047 ft.	Stratovol-cano	~40,000 – 14,000 YBP	High to very high	Sisters (OR); Bend (OR); Redmond (OR); Sunriver (OR); La Pine (OR); Blue River (OR); McKenzie Bridge (OR); Vida (OR); Springfield (OR)	Potentially active, capable of large explosive eruptions, ash fall, pyroclastic flows, lava flows and domes, and lahars.Scott and others (2001); Schilling and others (2008c).

South Sister	10,358 ft.	Stratovol-cano	~50,000 – 2,000 YBP	High to very high	Sisters (OR); Bend (OR); Redmond (OR); Sunriver (OR); La Pine (OR); Blue River (OR); McKenzie Bridge (OR); Vida (OR); Springfield (OR)	Potentially active, capable of large explosive eruptions, ash fall, pyroclastic flows, lava flows and domes, and lahars. Most silicic of the cones in the Three Sisters complex. Phase of uplift started in 1997 within a broad area about 6 km west of South Sister. Scott and others (2001); Schilling and others (2008c).
Broken Top	9,152 ft.	Stratovol-cano	300,000 - 100,000 YBP	Low to very low	Bend (OR); Sunriver (OR); La Pine	Deep glacial erosion; Lava flows, pyroclastic flows, ash fall. No hazard study
Mount Bachelor	9,068 ft.	Mafic volcano	~18,000 – 7,700 YBP	Moderat e	Bend (OR); Sunriver (OR); La Pine (OR);	Lava flows and near vent cinder and ash falls. No hazard study.
Newberry Volcano	7,986 ft.	Shield volcano/ caldera	~400,000 – 1,300 YBP	High to very high	Bend (OR); Sunriver (OR); La Pine (OR);	Potentially active and capable of large explosive eruptions. Lava flows and near vent cinder and ash falls. Present day hot springs. Sherrod and others (1997); Schilling and others (2008b).
Mount Thielsen	9,187 ft.	Shield volcano	> 250,000	Low to very low	Chemult (OR);	Deep glacial erosion; Lava flows, pyroclastic eruptions. No hazard study.
Crater Lake Caldera (Mount Mazama)	8,159 ft.	Caldera	~420,000 – 7,700 YBP	High to very high	Grants Pass (OR); Roseburg (OR); Chemult (OR); La Pine (OR); Fort Klamath (OR);	Lava flows, pyroclastic flows, ash fall. Source of the widespread Mazama ash. Bacon and others

					Chiloquin (OR); Klamath Falls (OR)	(1997).
Mount McLaughlin	9,496 ft.	Stratovol-cano	>80,000 YBP	Low to very low	Medford (OR); Grants Pass (OR); Klamath Falls (OR)	Lava flows, pyroclastic flows. No hazard study.

Source: Source: U.S. Geological Survey, Cascades Volcano Observatory: http://volcanoes.usgs.gov/observatories/cvo/
Wolfe and Pierson (1995); Scott and others (1995); Sherrod and others (1997); Scott and others (1997); Bacon and others (1997); Walder and others (2000); Scott and others (2001).

Mount St. Helens (WA)

The May 18, 1980, eruption of Mount St. Helens is the best-known example of volcanism to most Oregonians. That eruption included a debris avalanche, as part of the volcanic edifice collapsed (Figure 2-V-7). This caused a lateral blast of rock, ash, and gas that devastated areas to the north of the volcano. Lahars rushed down the Toutle and Cowlitz River valleys, reaching the Columbia River and halting shipping for some time. All other river valleys on the volcano experienced smaller lahars. Pyroclastic flows devastated an area up to five miles north of the volcano. Ash fall deposits affected people as far away as Montana, and ash circled the earth in the upper atmosphere for over a year.

Except for the debris avalanche and lateral blast, the events of this eruptive period are typical of a Mount St. Helens eruption and can be expected to occur again (Table 2-V-1). The primary hazards that will affect Oregonians are ash fall and lahars that affect the Columbia River. Since the major eruptive activity in the early 1980s, Mount St. Helens has experienced two episodes of dome building activity. The latest activity lasted from 2004 until 2008. Another eruption from Mount Saint Helens is very likely in the near future.

Mount Adams (WA)

Mount Adams, located 35 miles north of Hood River, Oregon, is the largest active volcano in Washington State and among the largest in the Cascade Range (Table 2-V-1). The volcano was active from about 520,000 to about 1,000 years ago. Eruptions from Mount Adams within the last 500,000 years have mainly consisted of effusive lava flows; highly explosive events are rare in the geologic record of Mount Adams. Eruptions have also occurred from ten vents in the vicinity of Mount Adams since the last period of glaciation about 15,000 years ago. Approximately 6,000 and 300 years ago, debris avalanches from the southwest face of Mount Adams generated clay-rich lahars that traveled down the White Salmon River. The summit of Mount Adams contains a large section of unstable altered rock that can spawn future debris avalanches and lahars.

Potential hazards from Mount Adams include lava flows near the central vent area and lahars that could reach and disrupt the Columbia River channel. Such lahars may have little or no advanced warning.

Mount Hood

The last major eruption of Mount Hood occurred in approximately 1781 (232 years ago)(Tables 2- V-1 and 2). The Sandy River that drains the volcano's northwest side was originally named the Quicksand River by Lewis and Clark, who traversed the area only a couple of years after an eruption. Lahars had

filled the river channel with debris, much of which has now been scoured away. There were two other minor periods of eruptions during the last 500 years, the last in the mid-1800s. Typically, these involved lava flows near the summit, pyroclastic flows, and lahars but little ash fall. From its recent eruptive history, the volcano is most likely to erupt from the south side, but planning should be done assuming eruptions could be centered anywhere on the mountain. A large eruption could generate pyroclastic flows and lahars that could inundate the entire length of the Sandy and White River Valleys. An eruption from the north flank could affect the Hood River Valley.

Due to its proximity to the Portland metropolitan area, major east-west highways, the Bull Run Reservoir (which supplies water to a majority of Portland area residents), and ski and summer recreation areas, Mount Hood poses the greatest potential volcanic hazard to Oregonians. In addition, a large volume of debris and sediment in lahars could affect shipping lanes in the Columbia River and operation of Bonneville and The Dalles dams.

In recent years, numerous debris flows caused by winter storms have flowed down river drainages. Highway 35 is periodically closed for repair work after these events damaged the bridge over the White River. If a volcanic event occurred, the same drainages would be affected.

Text Version

Mount Hood, Oregon
Notable Geologic Events Near Mount Hood, Oregon
-- In the Past 50,000 Years --

-- Excerpt from: Scott, Gardner, Sherrod, Tilling, Lanphere, and Conrey, 1997, Geologic History of Mount Hood Volcano, Oregon -- A Field-Trip Guidebook: U.S. Geological Survey Open-File Report 97-263, p.7.

Date or Age	Event	Deposits
A.D. 1859, 1865, 1907?	Minor explosive eruptions of Mount Hood	Scattered pumice
late 19th century	Late neoglacial advance	Prominent, sharp-crested moraines
late 18th century	Old Maid eruptive period	Lava dome, pyroclastic-flow and lahar deposits, tephra
about 500 years ago	Debris flows in Zigzag River	Debris-flow deposits
1,000 years ago	Debris flows in upper Sandy River	Debris-flow deposits
1,500 years ago	Timberline eruptive period	Lava dome, pyroclastic-flow and lahar deposits, tephra
7,700 years ago	Eruptions from vent near Parkdale; Mount Mazama ashfall	Basaltic andesite of Parkdale lava flow; about 5 centimeters of Mazama ash
11-20,000 years ago	Waning phases of Evans Creek glaciation	Moraines
13-20,000 years ago	Polallie eruptive period	Lava domes, pyroclastic-flow and lahar deposits, tephra
20-25,000 years ago	Maximum of Evans Creek glaciation	Belts of moraines in most valleys
20-30,000 years ago	Mount Hood dome eruptions	Lava domes, pyroclastic-flow and lahar deposits
30(?)-50,000(?) years ago	Mount Hood lava-flow eruptions	Andesite lava flows of Cathedral Ridge and Tamanawas Falls

Table 2-V-2: Notable Geologic Events Near Mt. Hood

Photo source: Bill Burns, DOGAMI

Mount Jefferson

Mount Jefferson is located in a relatively unpopulated part of the Cascade Range. The last eruptive episode at Mount Jefferson was about 15,000 years ago. Research at stratovolcanoes around the world indicates that Mount Jefferson should be regarded as dormant, not extinct.

The steep slopes of the volcano provide the setting for possible debris flows and lahars, even without an eruption. These would be confined to valleys, generally within 10 miles of the volcano.

A major eruption, however unlikely in the short term, could generate pyroclastic flows and lahars that would travel up to a few dozen miles down river valleys. Two reservoirs could be affected by pyroclastic flows from a major eruption: Detroit Lake and Lake Billy Chinook. An explosive eruption could spew ash for hundreds of miles in the downwind direction.

Many smaller volcanoes are located between Mount Jefferson and Mount Hood to the north and Three Sisters to the south. Eruptions from any of these would be primarily erupt *cinders* and ash to form cinder cones.

Three Sisters Region

North Sister has probably been inactive for at least 100,000 years (Table 2-V-1). Middle Sister last erupted between 25,000 and 15,000 years ago. South Sister had a very small ongoing uplift, which began in 1996 and became undetectable by 2003. The uplift was about one inch a year and likely indicated movement of a small amount of magma. At this writing, there is no indication that the uplift will ever develop into a volcanic eruption. However, that possibility cannot be ruled out. Hence, the Cascade Volcano Observatory has increased their monitoring of the area over the past several years.

Future eruptions at South Sister (and possibly Middle Sister) are likely to include lava flows, pyroclastic flows, and lahars. The possibility exists for lahars to travel many miles down valley floors, if an eruption melts a large amount of snow and ice. Ash fall would likely be contained within 20 miles of the vent.

Newberry Volcano

Newberry Volcano, unlike the stratovolcanoes of the Cascade Range, is a shield volcano with broad, relatively gently sloping flanks composed of stacked basaltic lavas flows (Table 2-V-1). The volcano is about 400,000 years old and has had thousands of eruptions both from the central vent area and along its flanks. The present 4 by 5 mi wide caldera at Newberry Volcano's summit formed about 75,000 years ago by a major explosive eruption and collapse event. This was the most recent of at least three caldera-forming eruptions that lofted pumice and ash high into the air and spread pyroclastic flows across the volcano's surface. The most recent eruption was 1,300 years ago when the “Big Obsidian Flow”, a glassy rhyolitic lava flow, erupted within the caldera. Future eruptions are likely to include lava flows, pyroclastic flows, lahars, and ash fall. Newberry Volcano has attracted interest for its geothermal potential. The heat under the volcano, with temperatures in some areas in excess of 509 degrees Fahrenheit, is evidence that it is only dormant.

Crater Lake Caldera

About 7,700 years ago, Mount Mazama erupted with great violence, leaving the caldera that Crater Lake now occupies (Table V-1). Layers of ash produced from that eruption have been found in eight western states and three Canadian provinces. The countryside surrounding Crater Lake was covered by

pyroclastic flows. Wizard Island is the result of much smaller eruptions since that cataclysm. The most recent eruption was about 5,000 years ago and occurred within the caldera. No eruptions have occurred outside the caldera since 10,000 years ago.

This potentially active volcanic center is contained within Crater Lake National Park. The western half of the caldera is considered the most likely site of future activity. Effects from volcanic activity (e.g., ash fall, lava flows) are likely to remain within the caldera. If an eruption occurs outside the caldera, pyroclastic flows and lahars could affect valleys up to a few dozen miles from the erupting vent. The probability of another caldera-forming eruption is very low, as is the probability of eruptions occurring outside the caldera.

Other Volcanic Areas of Oregon

On the scale of geologic time, volcanic eruptions may occur in other parts of Oregon. However, on a human time scale, the probability of an eruption outside the Cascades is so low as to be negligible.

Although the high, snow-topped mountains of the Cascades are Oregon's most visible volcanoes, other potential eruptive centers exist. These include smaller peaks, such as the Belknap shield volcano in central Oregon, which had a lava flow about 1,400 years ago. Several smaller volcanoes, including Diamond Craters and Jordan Craters, in the High Lava Plains of southeast Oregon have experienced recent eruptions in the last 7,000 years. Generally non-explosive eruptions at these sites have built complexes of lava flow fields and cinder cones. Hazards associated with future eruptions in sparsely populated southeast Oregon would most likely include lava flows covering many square miles; ash and volcanic gases derived from these eruptions may be regionally significant.

Historic Volcanic Events

Table 2-V-3 lists historic volcanic events in Oregon in the last 20,000 years.

Table 2-V-3: Historic Volcanic Events in Oregon

Date	Location	Description
~18,000 to 7700 YBP	Mount Bachelor, central Cascades	Cinder cones, lava flows
~20,000 -13,000 YBP	Polallie Eruptive episode, Mount Hood	Lava dome, pyroclastic flows, lahars, tephra
~13,000 YBP	Lava Mountain, south-central Oregon	Lava Mountain field, lava flows
~13,000 YBP	Devils Garden, south-central Oregon	Devils Garden field, lava flows
~13,000 YBP	Four Craters, south-central Oregon	Four Craters field, lava flows
~7,780 to 15,000 YBP	Cinnamon Butte, southern Cascades	Basaltic scoria cone and lava flows
~7700 YBP	Crater Lake Caldera	Formation of Crater Lake caldera, pyroclastic flows, widespread ash fall.
~7700 YBP	Parkdale, north-central Oregon	Eruption of Parkdale lava flow.
<7000 YBP	Diamond Craters, eastern Oregon	Lava flows and tephra in Diamond Craters field.
< 7700 YBP; 5300 – 5600 YBP	Davis Lake, southern Cascades	Lava flows and scoria cones in Davis Lake field.
~10,000 - <7,700 YBP	Cones south of Mount Jefferson; Forked Butte and South Cinder Peak	Lava flows
~4000 – 3000 YBP	Sand Mountain, central Cascades	Lava flows and cinder cones in Sand Mountain field.
< 3200 YBP	Jordan Craters, eastern Oregon	Lava flows and tephra in Jordan Craters field.
~3000 - 1500 YBP	Belknap Volcano, central Cascades	Lava flows, tephra
~ 2000 YBP	South Sister Volcano	Rhyolite lava flow.
~1500 YBP	Timberline eruptive period, Mount Hood	Lava dome, pyroclastic flows, lahars, tephra
~1300 YBP	Newberry Volcano, central Oregon	Eruption of Big Obsidian flow.
~1300 YBP	Blue Lake Crater, central Cascades	Spatter cones and tephra
1760-1810	Crater Rock/Old Maid Flat on Mount Hood	Pyroclastic Flows in upper White River; lahars in Old Maid Flat; dome building at Crater Rock
1859/1865	Crater Rock on Mount Hood	Steam explosions/tephra falls
1907 (?)	Crater Rock on Mount Hood	Steam explosions
1980	Mount St. Helens (WA)	Debris avalanche, ash fall, flooding

		on Columbia River
1981-1986	Mount St. Helens (WA)	Lava dome growth, steam, lahars
1989-2001	Mount St. Helens (WA)	Hydrothermal explosions
2004-2008	Mount St. Helens (WA)	Lava dome growth, steam, ash

Sources: Source: Source: U.S. Geological Survey, Cascades Volcano Observatory: http://volcanoes.usgs.gov/observatories/cvo/
Wolfe and Pierson (1995); Sherrod and others (1997); Scott and others (1997); Bacon and others (1997); Walder and others (2000); Scott and others (2001).

Probability

Geologists can make general forecasts of long-term volcanic activity from careful characterization of past activity, but they cannot supply a timeline. Several U.S. Geological Survey open-file reports provide the odds of certain events taking place at particular volcanoes. However, the U.S. Geological Survey stresses that government officials and the public must realize the limitations in forecasting eruptions and be prepared for such uncertainty.

Short-range forecasts, on the order of months or weeks, are often possible. There are usually several signs of impending volcanic activity that may lead up to eruptions. The upward movement of magma into a volcano prior to an eruption generally causes a significant increase in small, localized earthquakes and an increase in emission of carbon dioxide and compounds of sulfur and chlorine that can be measured in volcanic springs and the atmosphere above the volcano. Changes in the depth or location of magma beneath a volcano often cause changes in elevation. These changes can be detected through ground instrumentation or remote sensing (for example, this was how the South Sister Bulge uplift was discovered).

The Cascades Volcanic Observatory (CVO) employs scientists from a range of disciplines to continually assess and monitor volcanic activity in the Cascade Ranges. If anomalous patterns are detected (for example, an increase in earthquakes), CVO staff coordinate the resources necessary to study the volcano

Wildfire

Wildfire is a common and widespread natural hazard in Oregon; the state has a long and extensive history of wildfire. A significant portion of Oregon's forestland is dominated by ecosystems dependent upon fire for their health and survival. In addition to being a common, chronic occurrence, wildfires frequently threaten communities. These communities are often referred to as the "wildland-urban interface" (WUI), the area where structures and other human development meet or intermingle with natural vegetative fuels.

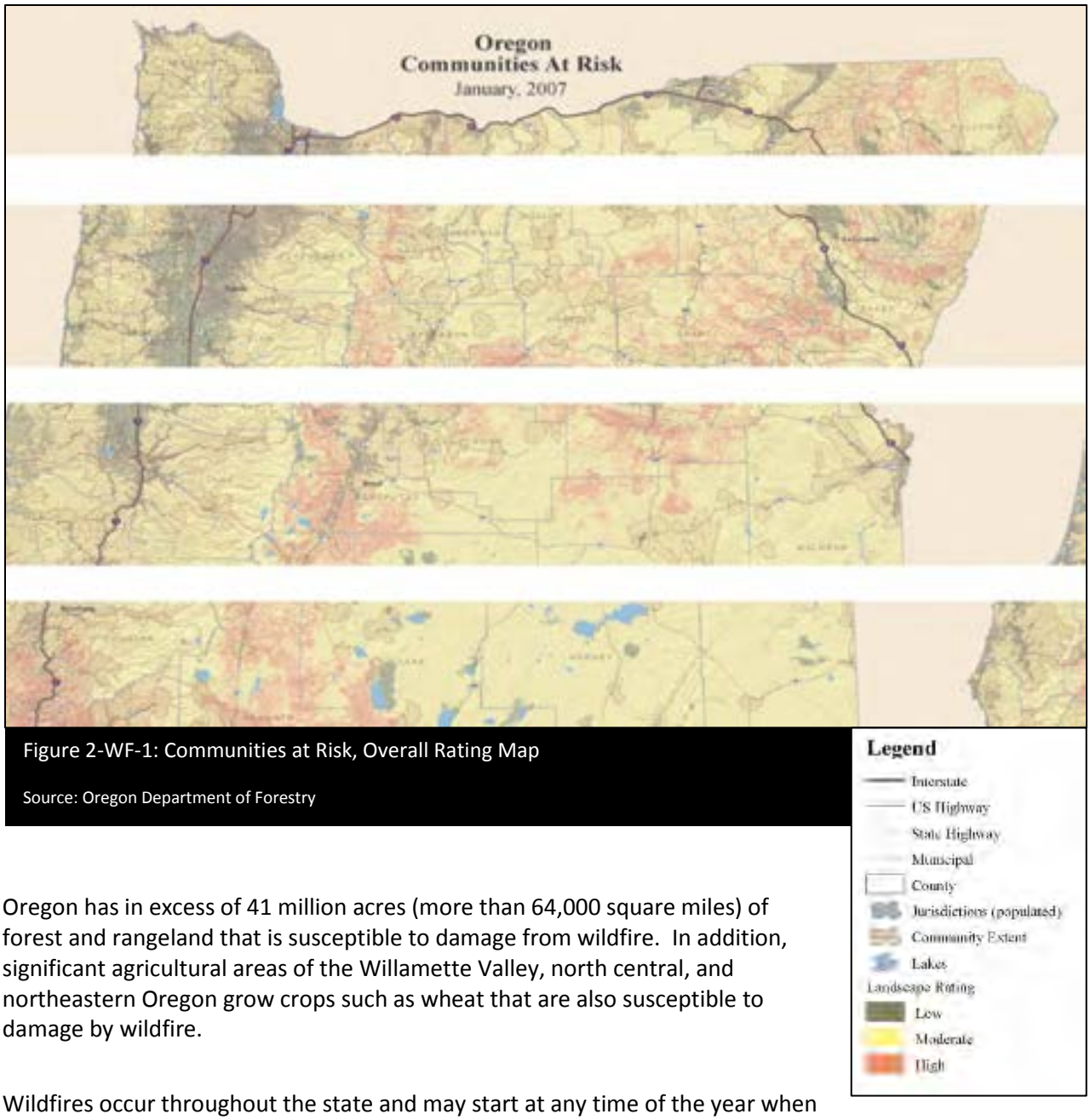

Figure 2-WF-1: Communities at Risk, Overall Rating Map

Source: Oregon Department of Forestry

Oregon has in excess of 41 million acres (more than 64,000 square miles) of forest and rangeland that is susceptible to damage from wildfire. In addition, significant agricultural areas of the Willamette Valley, north central, and northeastern Oregon grow crops such as wheat that are also susceptible to damage by wildfire.

Wildfires occur throughout the state and may start at any time of the year when weather and fuel conditions combine to allow ignition and spread.

Figure 2-WF-2: OEM Hazard Mitigation Regions

Source: OEM

The majority of wildfires take place between June and October, and primarily occur in the Oregon Office of Emergency Management's (OEM's) Hazard Mitigation Regions 4, 5, 6 and 7 (Figure 2-WF-2). However, even areas classified as low or moderate are susceptible to wildfires if the right combination of fuels, weather, and ignition conditions exist. Historically, Oregon's largest wildfires have burned in the Coast Range (Regions 1 & 2) where the average rainfall is high, but heavy fuel loads created low frequency, high intensity fire environment during the dry periods.

According to OEM, extreme winds are experienced in all of Oregon's eight regions. The most persistent high winds occur along the Oregon Coast and the Columbia River Gorge. The Columbia Gorge is the most significant east-west gap in the mountains between California and Canada. It serves as a funnel for east and west winds, where direction depends solely on the pressure gradient. Once set in motion, the winds can attain speeds of 80 mph. Wind is a primary factor in fire spread, and can significantly impede fire suppression efforts.

Historically, seventy percent of the wildfires suppressed on lands protected by the Oregon Department of Forestry (ODF) result from human activity. The remaining thirty percent result from lightning. Typically, large wildfires result primarily from lightning in remote, inaccessible areas.

According to a University of Oregon Study (The Economic Impacts of Large Wildfires) conducted between 2004 and 2008, the the financial and social costs of wildfires impact lives and property, as well as the negative short and long-term economic and environmental consequences they cause.

El Niño winters can be warmer and drier than average in Oregon. This often leads to an increased threat for large wildfires the following summer and autumn.

ODF's analysis of large fire potential is nearly complete: 12 of 14 identified Fire Danger Rating Areas have completed their analysis. These analyses will be reevaluated annually based on each year's weather and fire occurrence data. State firefighting agencies will continue to monitor correlations between seasonal weather conditions and wildfire occurrences and severity to refine planning tools for fire seasons and to aid in the pre-positioning of firefighting resources to reduce the vulnerability posed by large wildfires to natural resources and structures.

Figure 2-WF-3: ENSO and Wildfire Hazards

Life safety enhancement and cost savings may be realized by appropriate mitigation measures, starting with coordinated fire protection planning by local, state, tribes, federal agencies, the private sector, and community organizations. Additionally, and often overlooked, is the role that individual WUI property owners should play in this coordinated effort.

Wildfire suppression costs escalate dramatically when agencies must adjust suppression tactics because of the presence of structures. Additionally, the associated costs of structural protection also rise significantly, especially when there is a need to mobilize personnel and equipment from across the state. Costs may also be incurred by non-fire agencies in order to provide or support evacuations, traffic control, security, public information, and other needed support services during WUI fire incidents. These other agency costs vary widely and have not been well documented.

The number of people living in Oregon's WUI areas is increasing. Where people move into these areas, the number of wildfires has escalated dramatically. Many people arriving from urban settings expect a level of fire protection similar to what they had prior to moving. The reality is many WUI homes are located in portions of the state with limited capacity structural protection and sometimes no fire protection whatsoever. Many Oregon communities (incorporated and unincorporated) are within or abut areas subject to serious wildfire hazards. In Oregon, there are about 240,000 homes worth around $6.5 billion within the WUI. Such development has greatly complicated firefighting efforts and significantly increased the cost of fire suppression. While Oregon's Emergency Conflagration Act helps protect WUI communities who've depleted their local resources when threatened by an advancing wildfire, the escalating number of fires has led to the recognition that citizens in high fire risk communities need to provide mitigation and an appropriate level of local fire protection. Oregon's seller disclosure requires a statement of whether or not property is classified as forestland-urban interface. Collaboration and coordination is ongoing among several agencies to promote educational efforts through programs like Firewise, the Oregon Forestland Urban Interface Fire Protection Act, and Fire Adapted Communities from the National Cohesive Wildfire Strategy.

While many homes already exist in WUI areas, increasing construction in vulnerable areas also increases risk for vulnerable populations. The initial role of land use, such as Oregon's Goal 4 and Goal 7 play critical roles and guidance to development in these areas[32]. Life safety enhancement and cost saving mitigation measures include Community Wildfire Protection Plans (CWPP), coordinated fire protection planning and coordination by local, state, tribal, federal agencies, the private sector, and community organizations. Many local communities use their CWPP as their wildland fire chapter in their Local Natural Hazards Mitigation Plan (LNHMP).

Overabundant, dense forest fuels, particularly on public lands, are a focus of mitigation discussion. The Healthy Forest Restoration Act is focused on reducing overly dense vegetation and trees to create fuel breaks, provide funding and guidance to reduce or eliminate hazardous fuels in National Forests, improve forest fire fighting, and research new methods to reduce the impact of invasive insects. Oregon's efforts in and near WUI areas are a massive task, but are resulting in improvements. Not only does it take many years, sustaining the work requires a substantial, ongoing financial commitment.

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[32] Oregon's Statewide Planning Goals http://oregon.gov/LCD/goals.shtml#Statewide_Planning_Goals

Progress is often challenging because fuel mitigation methods are not universally accepted and are often controversial. However, recurring WUI fires continue to bring the issue into public focus as well as unite communities and stakeholders in a common set of values.

Analysis and Characterization

History of Wildfire

Wildfires have been a feature of the Oregon landscape for thousands of years. Prehistoric fires resulted from lightning and from the practices of Native Americans. The Blue Mountains in northeastern Oregon were named by early immigrants, because of the existence of a perpetual, blue colored wildfire smoke haze that lingered over the region. Between 1840 and 1900, wildland fires burned at least two million acres of forestland in western Oregon. It is believed settlers caused many of these fires. Following the establishment of the U.S. Forest Service and Oregon Department of Forestry, in 1905 and 1911, respectively, an aggressive and coordinated system of fire prevention and suppression emerged. However, it took several decades before significant gains were made.

Major wildfires in 1933, 1939, 1945 and 1951 burned across more than 355,000 acres in the northern Coast Range and became known collectively as the "Tillamook Burn."

Better suppression and more effective fire prevention campaigns combined to reduce large wildfire occurrences following World War II. Suppression improvements included the establishment of organized and highly trained crews, which replaced the previous system of hiring firefighters on an as-needed basis. Additional improvement resulted from construction of an extensive system of forest roads, lookouts and guard stations, the use of aircraft for the detection of fires and the delivery of fire suppression retardant, the invention and modification of modern and efficient fire suppression equipment, and refinements in weather forecasting and fire reporting. Prevention benefited from war-era campaigns, which united prevention activities with patriotism, and birthed movements such as the Smokey Bear campaign and the Keep Oregon Green Association.

Project Wildfire is the result of a Deschutes County effort to create long-term wildfire mitigation strategies and provide for a disaster-resistant community. Project Wildfire is the community organization that facilitates, educates, disseminates and maximizes community efforts toward effective fire planning and mitigation.

Project Wildfire achieves its mission by:

- Developing long-term wildfire prevention and education strategies designed to reach an ever-changing community.
- Creating disaster r131resistant communities through collaboration with community members and a network of specialized partners.
- Reducing the severity and amount of damage caused by wildfire in wildland urban interface (WUI) areas through hazardous fuels reduction programs.
- Reducing the impact of fuels reduction on the environment by recycling the woody biomass resulting from hazardous fuels reduction projects.

Figure WF-4: Project Wildfire

Source: ODF, website: http://www.projectwildfire.org

A pattern of frequent, large WUI fires emerged during the 1970s as people began flocking to more rural settings. Suburban growth increased and continued through the 1980s. This introduced substantially more structures into what had previously been wildland areas that historically depended on periodic fires to sustain a healthy forest ecosystem.

By the early 1990s, frequent, destructive WUI fires had become a major concern of the State Forester, the State Fire Marshal, and the Oregon Legislature. By the mid-1990s, over 100 structures had been destroyed by wildfires. Thousands more had been threatened and suppression costs were increasing sharply. The same trends were occurring in surrounding states, but at an even greater pace.

Oregon Forestland-Urban Interface Fire Protection Act

In 1988, following the very difficult and expensive fire season of 1987, Oregon developed An Action Plan for Protecting Rural/Forest Lands from Wildfire. The work was funded by the federal (FEMA) Fire Suppression Assistance (FSA) Program. The action plan was updated in 1991 with an Awbrey Hall Fire Appendix, in response to a fire which burned 22 structures on the western fringe of Bend. The 1988 action plan and the 1991 update led to the Legislature's attachment of a Budget Note to ODF's 1995-1997 budget, which required an examination of the WUI situation and the development of "*…recommendations which may include…statutory changes on how to minimize the costs and risks of fire in the interface*." Spurred by the loss of additional homes during the 1996 Skeleton Fire, these recommendations became the basis for passage of the *Oregon Forestland-Urban Interface Fire Protection Act of 1997*.

The Act recognized that "*…forestland-urban interface property owners have a basic responsibility to share in a complete and coordinated protection system*..." In addition, during the 1990s, prevention and mitigation of WUI fires included enactment of the Wildfire Hazard Zone process and the inclusion of defensible space requirements in the land use planning process. Significant efforts were made to increase voluntary landowner participation, through aggressive awareness campaigns, such as FireFree, Project Wildfire, Project Impact, Firewise, and other locally driven programs.

Through the years, Oregon's wildfire suppression system continued to improve. Firefighters benefited from improved training, coordination, and equipment. Better interagency initial attack cooperation, the growth of private crew and fire engine wildfire suppression resources, formation of structural incident management teams, and regional coordination of fire suppression are additional examples of these continued improvements. Technology has improved as well with the addition of lightning tracking software and fire detection cameras to support or replace deteriorating lookout towers.

Nevertheless, the frequency of wildfires threatening WUI communities continues to underscore the need for urgent action. The summer of 2002 included eleven Emergency Conflagration Act incidents, with as many as five running concurrently. More than 50 structures burned and, at one point, the entire Illinois Valley in Josephine County seemed under siege from the Biscuit Fire, Oregon's largest wildfire on record. This wildfire threatened the homes of approximately 17,000 people, with over 4,000 homes under imminent evacuation alert. At almost 500,000 acres, it was the nation's largest wildfire of the year. The summer of 2013 once again brought to bear one of the worst fire season's in Oregon. For the first time since 1951, more than 100,000 acres burned on lands protected by the Oregon Department of Forestry. Five incident management teams were deployed in a period of three days following a dry lightning thunderstorm event in late July that sparked nearly 100 fires in southern Oregon from more than 300 lightning strikes. Another storm that passed over central and eastern Oregon in mid-August produced significant fires that threatened the communities of John Day and The Dalles. Since 1996, Oregon has had 52 declared Conflagrations under the Act. Oregon's mitigation efforts since 2002 have

influenced a dramatic decrease in these types of fires, resulting in none to three per year through 2011. (see Appendix X for more information on Conflagration Fires from 1996 to 2011)

Types of Wildfire

Wildfires burn primarily in vegetative fuels located outside highly urbanized areas. Wildfires may be broadly categorized as agricultural, forest, range, or WUI fires.

Agricultural - Fires burning in areas where the primary fuels are flammable cultivated crops, such as wheat. This type of fire tends to spread very rapidly, but is relatively easy to suppress if adequate resources are available. Structures threatened are usually few in number and generally belong to the property owner. There may be significant losses in terms of agricultural products from such fires.

Forest - The classic wildfire; these fires burn in fuels composed primarily of timber and associated fuels, such as brush, grass, and logging residue. Due to variations of fuel, weather, and topography, this type of fire may be extremely difficult and costly to suppress. In wilderness areas these types of fires are often monitored and allowed to burn for the benefits brought by the ecology of fire, but also pose a risk to private lands when these fires escape these wilderness areas.

Range - Fires that burn across lands typically open and lacking timber stands or large accumulations of fuel. Such lands are used predominately for grazing or wildlife management purposes. Juniper, bitter-brush, and sage are the common fuels involved. These fires tend to spread rapidly and vary from being easy to difficult to suppress. They often occur in areas lacking both wildland and structural fire protection services.

Wildland-Urban Interface (WUI) - These fires occur in portions of the state where urbanization and natural vegetation fuels are mixed together. This mixture may allow fires to spread rapidly from natural fuels to structures and vice versa. Such fires are known for the large number of structures simultaneously exposed to fire. Especially in the early stage of WUI fires, structural fire suppression resources may be quickly overwhelmed, which may lead to the destruction of a large number of structures. Nationally, wildland interface fires have frequently resulted in catastrophic structure losses.

Increased risk of landslides and erosion are secondary hazards associated with wildfires that occur on steep slopes. Wildfires tend to denude the vegetative cover and burn the soil layer creating a less permeable surface prone to sheetwash erosion. This - in turn - increases sediment load and the likelihood of downslope failure and impact.

Wildfires can also impact water quality (e.g., drinking water intakes). During fire suppression activities some areas may need coordinated efforts to protect water resource values from negative impact.

Wildfire smoke may also have adverse effects on air quality health standards and visibility, as well as creating nuisance situations. Strategies to limit smoke from active wildfires are limited, but interagency programs exist to alert the public of potential smoke impact areas where hazardous driving or health conditions may occur.

Figure 2-WF-5: Secondary hazards

Common Sources of Wildfire

For statistical tabulation purposes, wildland fires are grouped into nine categories. These categories relate to the historically common wildfire ignition sources. Graphical information that displays trends for some of these sources may be found in Appendix X.

Lightning – There are tens of thousands of lightning strikes in Oregon each year. Of the ten categories, lightning is the leading ignition source of wildfires. In addition, lightning is the primary cause of fires which require utilization of Oregon's *Conflagration Act*.

Equipment Use – This source ranges from small weed eaters to large logging equipment; many different types of equipment may readily ignite a wildfire, especially if used improperly or illegally. Although fire agencies commonly limit or ban certain uses of fire prone equipment, the frequency of fires caused by equipment has been trending upward in recent years. This increase may be related to the expansion of the wildland interface, which results in more people and equipment being in close proximity to forest fuels.

Railroad – Wildfires caused by railroad activity are relatively infrequent. In the early twentieth century, this had been a major cause of fires, but has been decreasing for many years. Over the past ten-year period, the number of fires has leveled out. In the past few decades, Oregon has responded to railroad caused fires with aggressive fire investigation and cost recovery efforts. Oregon Department of Forestry works with the railroad on hazard abatement along tracks and requires water cars and chase vehicles during high fire danger. The resulting quick return to normal fire incidence showed that railroad fires are preventable.

Recreation – The trend in fires caused by people recreating in and near Oregon's forests has been rising over the past ten years. This trend may reflect the state's growing population and as well as a greater interest in outdoor recreation opportunities.

Debris Burning – Historically, fires resulting from debris burning activities has been a leading cause of human caused wildfires. Aggressive prevention activities, coupled with an increasing use of local burning bans during the wildfire season, has begun to show positive results. Many debris burning fires occur outside the confines of fire season, which has led to increased awareness during the spring and fall months leading into and out of fire season.

Juvenile – The trend in the incidence of juveniles starting wildland fires is downward in recent years. This is attributed to concerted effort by local fire prevention cooperatives to deliver fire prevention messages directly to school classrooms and the Office of the State Fire Marshall's (OSFM's) aggressive youth intervention program. In 1999, according to the ODF, juveniles were reported to have started 60 wildland fires. Conversely, juveniles accounted for just 17 fires in 2013 and, on average, have only accounted for 25 fires per year over the last 10 years. Additionally, parents or guardians, under Oregon Law, are responsible for damages done by fires started by their children. ORS 30.765 covers the liability of parents; ORS 163.577 holds parents or guardians accountable for child supervision; ORS 477.745 makes parents liable for wildfire suppression costs of a fire by a minor child; and ORS 480.158 holds a parent liable for fireworks caused fires. Additionally, parents may be assessed civil penalties.

Arson – Oregon experienced a rapid rise in the frequency of arson caused fires in the early '90s. 1992 was the worst fire season for arson with 96 fires attributed to the category. In response, the state

instituted aggressive arson prevention activities with solid working relationships with local law enforcement and the arson division of the Oregon State Police. The result has seen the 10-year average slightly decline with just 41 fires occurring annually since 2004.

Smoking – Fires caused by smoking and improperly discarded cigarettes is down. It is not known if this is due to fewer people smoking, recent modifications producing self extinguishing cigarettes, or better investigation of fire causes.

Miscellaneous – Wildfires resulting from a wide array of causes: automobile accidents, burning homes, pest control measures, shooting tracer ammunition and exploding targets, and electric fence use are a few of the causes in this category. The frequency of such fires has been rising in recent years.

Historic Wildfires in Oregon

Table 2-WF-1 lists historic wildfire in Oregon.

Table 2-WF-1: Historic Wildfires in Oregon

Date	Location	Description
1933 1939 1945 1951	Tillamook County	The Tillamook Burn included four fires occurring every six years over an 18 year period that burned 355,000 acres and killed one person.
1936	Bandon	This fire destroyed the town of Bandon, burned 400 structures and killed 11 people.
1951	Douglas County	The Hubbard Creek Fire burned 15,774 acres and destroyed 18 homes. The Russell Creek Fire burned 350 acres and killed one person.
1966	Douglas County	The Oxbow Fire burned 43,368 acres and killed one person.
1987	Douglas County	The Bland Mountain Fire burned 10,300 acres and 14 homes and killed two people.
1990	Deschutes County	The Awbrey Hall Fire burned 3,353 acres and destroyed 22 homes.
1992	Klamath County	The Lone Pine Fire burned 30,320 acres and destroyed 3 structures.
1994	Jackson County	Hull Mountain Fire burned 8,000 acres, destroyed 44 structures and killed one person.
1996	Deschutes County	Skeleton Fire burned 17,776 acres and destroyed 19 homes.
2002	Coos, Josephine, Jefferson, Deschutes Counties	Biscuit Fire burned 500,000 acres and destroyed 13 structures. Eyerly Fire burned 23,573 acres and destroyed 37 structures. Cache Mountain Fire burned 4,200 acres and destroyed 2 structures.
2010	Jackson County	Oak Knoll Fire in Ashland destroyed 11 homes in less than 45 minutes.
2011	Wasco County	High Cascade Complex burned on the east side of Mount Hood into Warm Springs, consuming 101,292 acres.
2012	Malheur, Harney	The Long Draw Fire consumed 557,648 acres.
2013	Douglas, Josephine, Wasco, Grant Counties	The most acres burned in the last 50 plus years during 2013. More than 100,000 acres burned and destroyed four homes. Three firefighter deaths were also attributed to the fires.

Source: Oregon Department of Forestry, 2013

Probability

Fire is a natural component of forest and rangeland ecosystems found in all portions of the state. Many of these ecosystems are dependent upon the existence of frequent fire, or on a viable substitute, for their continued existence. Even western Oregon forests, in the "wet" northwestern portion of the state, depend upon fire. It is a common myth that an unbroken carpet of old growth timber blanketed western Oregon prior to the beginning of European American settlement. In fact, fire and other natural forces had created a mosaic of different aged timber stands across the region. Factors now influencing the occurrence and severity of wildfires include poor forest health, invasive plant and tree species, high amounts of vegetation arising from long-term fire exclusion, changes in weather patterns, and the presence of humans and human development.

In Oregon, wildfires are inevitable. Although usually thought of as being a summer occurrence, wildland fires can occur during any month of the year. The vast majority of wildfires burn during the June to October time period. Dry spells during the winter months, especially when combined with winds and dead fuels, may result in fires that burn with an intensity and a rate of spread that surprises many people.

During a typical year, in excess of 2,500 wildland fires are ignited on protected forestlands in Oregon. On lands protected by ODF, the ten-year trend in both the incidence of human caused fires and the acres they burn across is rising. When compared to Oregon's rapidly increasing population, the trend in the number of human caused wildland fires has also been trending upward.

Windstorm

This section covers most kinds of windstorm events in Oregon, including the wind aspects of Pacific storm events. The precipitation aspects of Pacific storm events are covered earlier in the Flood section of this Plan (page 75). Winds specifically associated with blizzards and ice storms are covered in the Winter Storms section of this Plan (pg. 144).

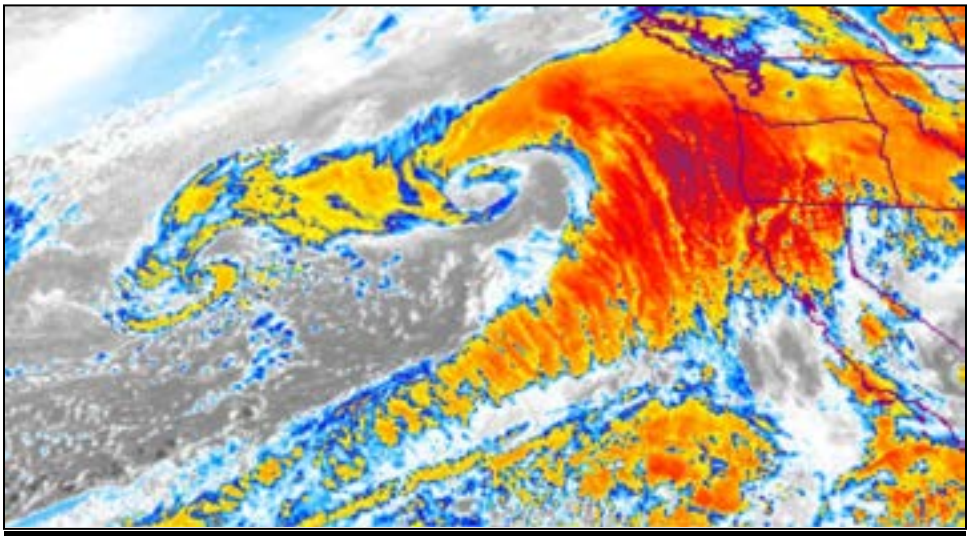

Figure 2-WI-1: Pacific Storms like this one not only bring heavy precipitation, but also often bring high winds to Western Oregon.

Source: NOAA

Analysis and Characterization

High winds can be among the most destructive weather events in Oregon; they are especially common in the exposed coastal regions and in the mountains of the Coast Range. Most official wind observations in Oregon are sparse, taken at low-elevation locations where both the surface friction and the blocking action of the mountain ranges substantially decrease the speed of surface winds. Furthermore, there are few long-term reliable records of wind available. Even the more exposed areas of the coast are lacking in any long-term set of wind records. From unofficial, but reliable observations, it is reasonable to assume that gusts well above 100 mph occur several times each year across the higher ridges of the Coast and Cascades Ranges. At the most exposed Coast Range ridges, it is estimated, that wind gusts of up to 150 mph and sustained speeds of 110 mph will occur every five to ten years.

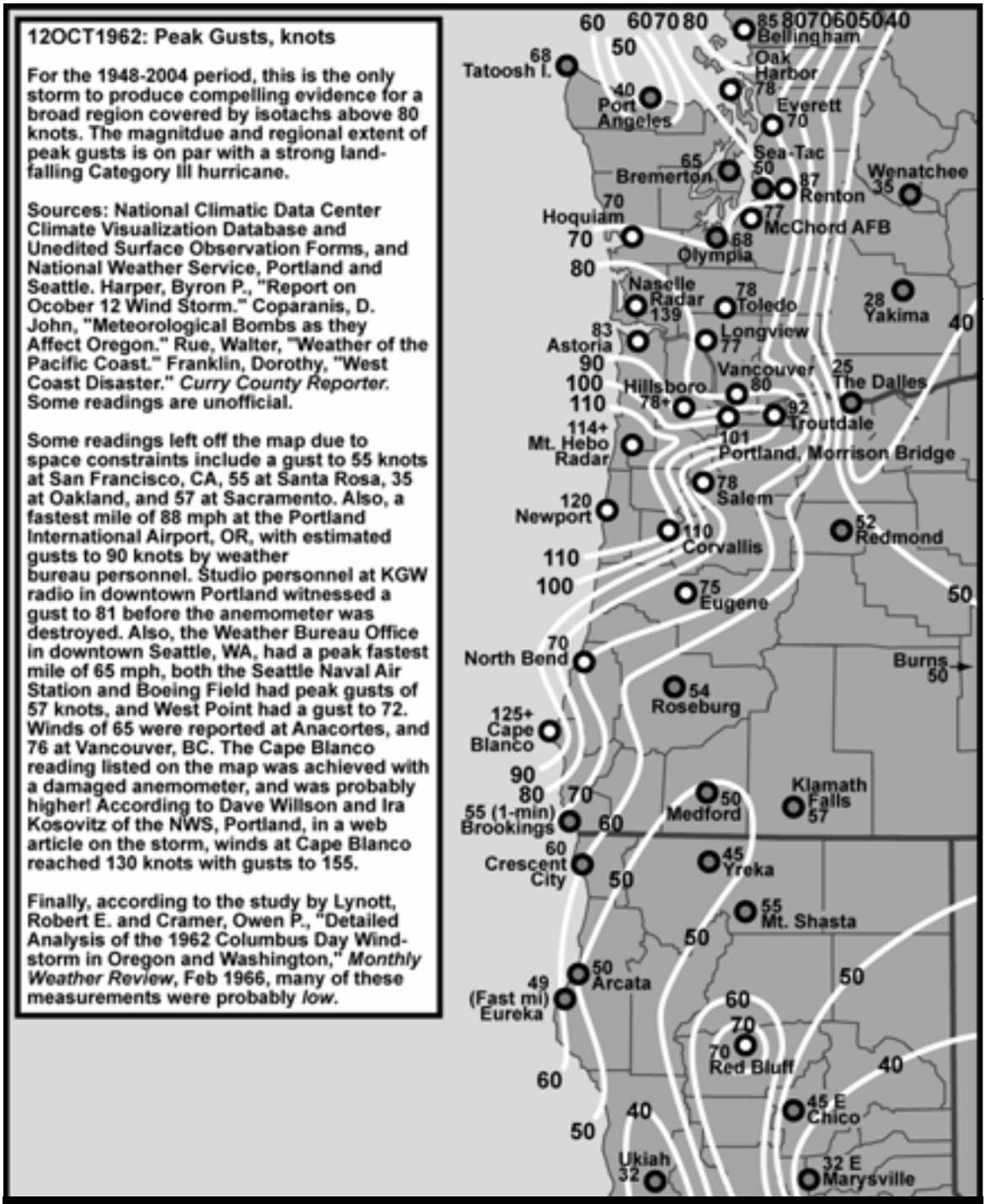

Figure 2-WI-2: Peak Gusts for windstorm on October 12, 1962

Source: Wolf Read, Climatologist, Oregon Climate Center at Oregon State University.

Figure 2-WI-3: Unstable trees left after a logging operation near electric lines pose a serious threat of personal injury, forest fire, and outages should high winds develop. Forest owners and workers need to coordinate their "leave trees" with electric utilities to prevent dangerous conditions as depicted here.

Photo source: Randy Miller, PacifiCorp.

Pacific storms can produce high winds, and often are accompanied by significant precipitation and low barometric pressure. These storms usually produce the highest winds in Western Oregon, especially in the coastal zone. These storms are most common from October through March. The impacts of these storms on the state are influenced by storm location, intensity, and local terrain.

The historian Lancaster Pollard documented exceptional storms that occurred in 1880, 1888, 1920, 1931, and 1962. On January 29, 1920 a hurricane off the mouth of the Columbia River had winds estimated at 160 miles per hour.[33]

One easterly windstorm that affected much of Oregon, particularly northern Oregon, was the northeasterly gale of April 21-22, 1931. This storm proved to be very destructive. Dust was reported by ships 600 miles out to sea. "While officially recorded wind speeds were not extreme, sustained wind speeds observed were 36 mph at Medford, 32 mph at Portland, 28 mph at Baker, and 27 mph at Roseburg. Unofficial wind measuring equipment reported winds of up to 78 mph. Damage was heavy to standing timber and fruit orchards." [34]

[33] *Pacific Northwest Quarterly,* "The Pacific Northwest Dust Storm of 1931," Paul C. Pitzer, April 1988, p. 50

[34] http://www.wrh.noaa.gov/Portland/windstorm.html - For more information on this 1931 storm, see the Dust Storms Chapter of this plan, especially Appendix DS-1.

Effects

The damaging effects of windstorms may extend for distances of 100 to 300 miles from the center of storm activity. Isolated wind phenomena in the mountainous regions have more localized effects. Near-surface winds and associated pressure effects exert loads on walls, doors, windows, and roofs, sometimes causing structural components to fail.

> Positive wind pressure is a direct and frontal assault on a structure, pushing walls, doors, and windows inward. Negative pressure also affects the sides and roof: passing currents create lift and suction forces that act to pull building components and surfaces outward. The effects of high velocity winds are magnified in the upper levels of multi-story structures. As positive and negative forces impact and remove the building protective envelope (doors, windows, and walls), internal pressures rise and result in roof or leeward building component failures and considerable structural damage.

Debris carried along by extreme winds can directly contribute to loss of life and indirectly to the failure of protective building envelope components. Upon impact, wind-driven debris can rupture a building, allowing more significant positive and internal pressures. When severe windstorms strike a community, downed trees, powerlines, and damaged property are major hindrances to response and recovery.

The most destructive winds are those which blow from the south, parallel to the major mountain ranges. The Columbus Day Storm of 1962 was a classic example of a south windstorm. The storm developed from Tyhoon Freda remnants in the Gulf of Alaska, deepened off the coast of California and moved from the southwest, then turned, coming into Oregon directly from the south. This was the most damaging windstorm in Oregon of the last century. Winds in the Willamette Valley topped 100 mph, while in the Coast Range they exceeded 140 mph. The Columbus Day Storm was the equivalent of a Category IV hurricane in terms of central pressure and wind speeds.

In terms of damage, "throughout the Willamette Valley, undamaged homes were the exception, not the rule. In 1962 dollars, the Columbus Day Storm caused an estimated $230-280 million in damage to property in California, Oregon, Washington and British Columbia combined, with $170-200 million happening in Oregon alone. This damage figure is comparable to eastern hurricanes that made landfall in the 1957-1961 time period...The (Columbus Day Storm) was declared the worst natural disaster of 1962 by the Metropolitan Life Insurance Company. In terms of timber loss, about 11.2 billion board feet was felled... in Oregon and Washington combined."[35] "The storm claimed 46 lives, injured hundreds more, and knocked power out for several million people.[36]

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[35] http://www.climate.washington.edu/stormking/

[36] http://www.wrh.noaa.gov/pqr/info/pdf/pacwindstorms.pdf

Other Issues

In the Hazard Mitigation Survey Team (HMST) Report developed in response to the February 7, 2002 windstorm the recommended observation issued that "differences in definitions of easements and allowable practices within them ('easement language') for private versus public, and urban forests vs. rural forests should be resolved." The State IHMT agencies agree that this issue continues to exist, but neither the resources nor the political will exist at this time to attempt to fix this complicated issue with many vested stakeholders.

Two other issues identified in that report also continue to exist, but cannot be solved at this time:

1. "Land use actions being proposed by agencies with non-utility interests, which would affect land for which utilities have an interest, should be coordinated and should address vegetation management as it affects utility system operations", and

2. "Agencies and organizations should be identified to work with federal and state landowners to streamline processes by which electric utilities conduct hazard mitigation work on those lands..." Currently, ODOT issues permits for right-of-way work and ODF issues permits for the use of power equipment in forested areas.

Other areas of ongoing concern from this HMST Report are:

- Under Coordination - Utility providers should receive notification, from property owners, of planned tree-harvesting operations near utility lines.
- Under Vegetation Management - Diseased, damaged, and hazard trees near powerlines that could fall or hit utility lines should be removed. Some "leave trees" remaining after new building developments and tree harvesting operations pose a threat to utility line safety and reliability. See Appendix W-3 to this chapter, *How to Recognize and Prevent Tree Hazards*, for progress that has been made towards vegetation management issues.
- Under Engineering, Construction, and Compliance - *"During initial planning and design of utility lines, identify types of geographic areas already known to pose hazards during windstorms. Inventory and analyze areas of repetitive failures to determine alternate designs and construction methods that will mitigate future damages... Consider selective undergrounding of lines where repetitive tree damage occurs, keeping in mind excavations can undermine tree root zones and create new hazards."*

Historic Windstorm Events in Oregon

Table 2-WI-1 summarizes selected significant windstorms in Oregon.

Table 2-WI-1: Historic Windstorms in Oregon

Month - Year	Location	Comments
October 1962	Western Oregon and locations east of Cascades, OR	Columbus Day Storm. Oregon's most famous and most destructive windstorm. Barometric pressure low of 960 mb (*).
March 1963	Western Oregon	Second strongest windstorm in the Willamette Valley since 1950.
October 1967	Most of Western and Central Oregon	An intense 977 mb low produced a sudden, destructive blow (*)
November 1981	Oregon Coast and N. Willamette Valley, OR	Back-to-back storms on the 13th and 15th of November.
January 1993	North Coast Range, OR	Inauguration Day Storm. Major disaster declaration in Washington State.
December 1995	Northwest Oregon	FEMA-1107-DR-OR (*). Strongest windstorm since Nov. 1981. Barometric pressure of 966.1 mb (Astoria), and *Oregon record low 953 mb (*off the coast).
February 2002	South and Central Coast, Southern Willamette Valley, OR	FEMA-1405-DR-OR. Surprise windstorm.
February 2007	Northwest & Central Coast and North Central Oregon	FEMA-1683-DR-OR. Severe winter storm with a wind component.
December 2007	South, Central, North Coast and Willamette Valley, OR	FEMA-1733-DR-OR. Severe winter storm, including flood and landslide events.

(*) For the sake of comparison, surface barometric pressures associated with Atlantic hurricanes are often in the range of 910 to 960 mb. The all-time record low sea level barometric pressure recorded was associated with Typhoon Tip in the Northwest Pacific Ocean on October 12, 1979 at 870 mb.

Sources: Oregon Climate Service; Pitzer (1988)[1]; and WRH[2].

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[1] *Pacific Northwest Quarterly,* "The Pacific Northwest Dust Storm of 1931," Paul C. Pitzer, April 1988, p. 50

[2] http://www.wrh.noaa.gov/Portland/windstorm.html - For more information on this 1931 storm, see the Dust Storms Chapter of this plan, especially Appendix DS-1.

Probability

Extreme weather events are experienced in all regions of Oregon. Areas experiencing the highest wind speeds are the Central and North Coast under the influence of winter low-pressure systems in the Gulf of Alaska and North Pacific Ocean; and the Columbia River Gorge, when cold air masses funnel down through the canyon in an easterly direction. For example, at Crown Point, located about 20 miles east of Portland, easterly winds with a 24-hour average of more than 53 mph and gusts in excess of 120 mph were recorded.

Table 2-WI-2: Probability of Severe Wind Events by OEM Hazard Mitigation Region (one-minute average, 30 feet above the ground

Location	25-Year Event (4% annual probability)	50-Year Event (2% annual probability)	100-Year Event (1% annual probability)
Region 1 - Oregon Coast	75 mph	80 mph	90 mph
Region 2 - Northern Willamette Valley	65 mph	72 mph	80 mph
Region 3 - Mid/Southern Willamette Valley	60 mph	68 mph	75 mph
Region 4 - Southwest Oregon	60 mph	70 mph	80 mph
Region 5 - Mid-Columbia	75 mph	80 mph	90 mph
Region 6 - Central Oregon	60 mph	65 mph	75 mph
Region 7 - Northeast Oregon	70 mph	80 mph	90 mph
Region 8 - Southeast Oregon	55 mph	65 mph	75 mph

Source: PUC

Additional wind hazards occur on a very localized level, due to several down-slope windstorms along mountainous terrain. These regional phenomena known as foehn-type winds, result in winds exceeding 100 mph, but they are of short duration and affect relatively small geographic areas. A majority of the destructive surface winds in Oregon are from the southwest. Under certain conditions, very strong east winds may occur, but these are usually limited to small areas in the vicinity of the Columbia River Gorge or in mountain passes.

The much more frequent and widespread strong winds from the southwest are associated with storms moving onto the coast from the Pacific Ocean. If the winds are from the west, they are often stronger on the coast than in the interior valleys due to the north-south orientations of the Coast Range and Cascades. These mountain ranges obstruct and slow down the westerly surface winds.

High winds occur frequently in Oregon, and they are especially common in coastal regions and in the mountains of the Coast Range between October and March. From unofficial but reliable observations, it is reasonable to assume that gusts well above 100 mph occur several times each year across the higher ridges of the Coast and Cascades Ranges. At the most exposed Coast Range ridges, it is estimated that wind gusts of up to 150 mph and sustained speeds of 110 mph will occur every five to ten years. The Willamette Valley may face 40 to 60 mile per hour winds from a 100 mph+ storm on the coast. Also, the Columbia River Gorge funnels very strong winds, often from east to west.

Winter Storm

Winter storms are among nature's most impressive spectacles. Their combination of heavy snow, ice accumulation, and extreme cold can totally disrupt modern civilization, closing down roads and airports, creating power outages, and downing telephone lines. Winter storms remind us how vulnerable we are to nature's awesome powers.

For the most part, the wind aspects of winter storms are covered in the Windstorms section of this Plan (pg. 137). Heavy precipitation aspects associated with winter storms in some parts of the state, which sometimes lead to flooding, are covered in the Flood section of this Plan (pg. 75). This winter storms section instead generally addresses snow and ice hazards, and extreme cold.

Analysis and Characterization

Snowstorms need two ingredients: cold air and moisture. Rarely do the two ingredients occur at the same time over western Oregon, except in the higher elevations of the Coast Range and especially in the Cascades. But snowstorms do occur over eastern Oregon regularly during December through February. Cold arctic air sinks south along the Columbia River basin, filling the valleys with cold air. Storms moving across the area drop precipitation, and if conditions are right, snow will occur.

Figure 2-WS -1: Troutdale area – December 1996

Photo Source: National Weather Service

However, it is not that easy a recipe for western Oregon. Cold air rarely moves west of the Cascades Range. The Cascades act as a natural barrier, damming cold air east of the range. The major spigot is the Columbia River Gorge, which funnels cold air into the Portland area. Cold air then begins deepening in the Columbia River Gorge, eventually becoming deep enough to sink southward into the Willamette Valley. If the cold air east of the Cascades is deep, it will spill through the gaps of the Cascades and flow into western valleys via the many river drainage areas along the western slope. Cold air in western Oregon is now in place. Now, the mechanism is to get a storm to move near or over the cold air, which will use the cold air and produce freezing rain, sleet and/or snow. Sometimes, copious amounts of snow are produced. Nearly every year, minor snowfalls of up to six inches occur in the western interior valleys. However, it is a rare occurrence for snowfalls of over a foot in accumulation.[37]

[37] National Weather Service – Portland, Oregon Forecast Office, *Historical Storms and Data—Oregon's Notable Historical Snowstorms,* Nov. 2013

Snow is relatively rare along the coast in Oregon. There is, however, a noticeable relationship between latitude and snowfall. Appendix WS-1 shows average annual snowfall at various Oregon stations. Notice, in particular, Crater Lake, one of the snowiest measurement stations in the United States, which once reported nearly 900 inches of snow in one season.[38]

Figure 2-WS-2: Shielded snow gauge used in the Pacific Northwest to register snowfall, 1917.

Source: National Weather Service

Ice storms and freezing rain can cause severe problems when they occur. The most common freezing rain events occur in the proximity of the Columbia Gorge. The Gorge is the most significant east-west air passage through the Cascades. In winter, cold air from the interior commonly flows westward through the Gorge, bringing very cold air to the Portland area. Rain arriving from the west falls on frozen streets, cars, and other sub-freezing surfaces, creating severe problems. As one moves away from the Gorge, temperatures moderate as the marine influence becomes greater and cold interior air mixes with milder west-side air. Thus freezing rain is often confined to areas in the immediate vicinity of the Gorge: Corbett, Troutdale, perhaps as far west as Portland Airport. Downtown Portland and the western and southern suburbs often escape with no ice accumulation.[39]

Freezing rain (also known as an ice storm) is rain that falls onto a surface with a temperature below freezing. The cold surface causes the rain to freeze so the surfaces, such as trees, utilities, and roads, become glazed with ice. Even small accumulations of ice can cause a significant hazard to property, pedestrians, and motorists.

Sleet is rain that freezes into ice pellets before reaching the ground. Sleet usually bounces when hitting a surface and does not stick to objects; however, it can accumulate like snow and cause roads and walkways to become hazardous.
Black ice can fool drivers into thinking water is on the road. What they may not realize is that condensation, such as dew, freezes when temperatures reach 32 degrees Fahrenheit (F) or below, forming a thin layer of ice. This shiny ice surface is one of the most dangerous road conditions. Black ice is likely to form under bridges and overpasses, in shady spots and at intersections.

Meteorologists define *heavy snow* as six inches or more falling in less than twelve hours, or snowfall of eight inches or more in twenty-four hours. A *blizzard* is a severe winter weather condition characterized by low temperatures and strong winds blowing a great deal of snow. The National Weather Service

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[38] Oregon Climate Service, The Climate of Oregon, From Rain Forest to Desert, Corvallis, Oregon 1999

[39] From *The Oregon Weather Book, A State of Extremes*, George Taylor and Raymond Hatton, OSU Press, 1999

defines a blizzard as having wind speeds of 35 mph or more, with a visibility of less than a quarter mile. Sometimes a condition known as a *whiteout* can occur during a blizzard. This is when the visibility drops to zero because of the amount of blowing snow.

Wind blowing across your body makes you feel colder. The *wind chill* factor is a measure of how cold the combination of temperature and wind makes you feel. Wind chill of 50 degrees or lower can be very dangerous: exposed skin can develop frostbite in less than a minute, and a person or animal could freeze to death after just 30 minutes of exposure.

A snow avalanche is a mass of snow falling down a mountain or incline. Three variables interact to determine whether an avalanche is possible:

1. Terrain: the slope must be steep enough to avalanche.
2. Snowpack: the snow must be unstable enough to avalanche.
3. Weather: changing weather can quickly increase instability.

According to the Northwest Weather and Avalanche Center, avalanches don't happen by accident and most human involvement is a matter of choice, not chance. Most avalanche accidents are caused by slab avalanches that are triggered by the victim or a member of the victim's party. However, any avalanche may cause injury or death and even small slides may be dangerous.

On average, about 30 people in the United States are killed in avalanches each year. For the 21 years between 1985 and 2006. Oregon ranks 10th among the states for avalanche fatalities with five fatalities. This is based on statistics from the Colorado Avalanche Information Center. Avalanche victims are almost exclusively backcountry recreationists—snowmobilers, climbers, snowboarders, snowshoers, skiers, and hikers. Nationally snowmobilers lead the list with twice as many fatalities as any other activity.

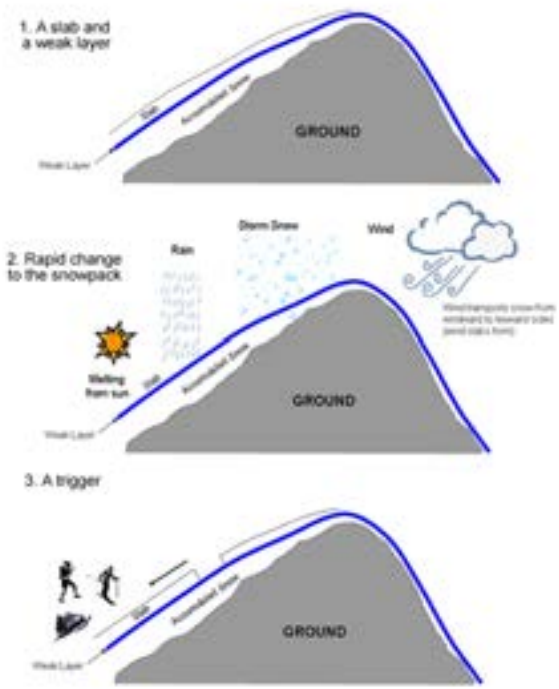


Figure 2-WS-3: Ingredients for a Slab Avalanche

Source: Northwest Weather and Avalanche Center

According to Portland Mountain Rescue, most avalanche victims triggered the very avalanche that caught them. The group advises people to be aware of the constantly changing conditions in the backcountry and take a certified avalanche class to increase their avalanche awareness.

Ski areas are different from the backcountry. It is very rare for someone to get caught in an avalanche within a ski area. Professional snow safety crews rely on explosives and ski compaction to stabilize ski area snowpack.

Historical Winter Storm Events in Oregon

Table 2-WS-1 lists historic winter storms in Oregon.

Table 2-WS-1: Historical Winter Storms in Oregon

Date	Location	Description
December 16 to 18, 1884	Linn, Marion, Washington, Multnomah, Hood River and Wasco counties	Heavy snow in the Columbia River Basin from Portland to The Dalles and along the Cascades foothills in the Willamette Valley. One-Day snow totals: Albany 16.0 inches, The Dalles 29.5 inches, Portland 12.4 inches
December 20 to 23, 1892	Linn, Marion, Washington, Multnomah, Umatilla counties	Substantial snow across most of northern Oregon. Greatest snowfall in the northwest part of the state, totals from (15 to 30 inches) with Albany 15.0 inches, Corvallis 14.0 inches, Portland 27.5 inches, Forest Grove 28.0 inches, Pendleton 8.0 inches
January 5 to 10, 1909	Josephine, Jackson, Douglas Lane, Linn, Marion, Clackamas, Hood River, Waco counties	Heavy snowfall in mountainous areas. 34.5 inches at Siskiyou Summit. Many locations, particularly in western Oregon, received more snow in this six-day period than they normally would receive in an entire year. Snow totals: Ashland 9.1 inches, Eugene 15.1 inches, Forest Grove 29.0 inches, Lakeview 17.0 inches, Portland 19.3 inches, The Dalles 14.5 inches
January 11 to 15, 1916	Josephine, Jackson, Douglas Lane, Linn, Marion, Clackamas, Hood River, Waco counties	5-8 inches of snow in western Oregon, except for the southwestern interior and the coastal areas, McMinnville. had the most snow in one day, with 11 inches falling on January 12. Another 24 inches at Siskiyou Summit, Higher elevations in the Cascades received very heavy snowfall
January 30 to February 3, 1916	Hood River, Clackamas, Marion, Wasco, Jefferson, Multnomah counties	Snow and Ice storm along the northern Oregon border. Heaviest snowfall in the Hood River Valley with 29.5 inches in one day at Parkdale, and81.5 inches total. Heavy snow especially in the higher Cascades with Government Camp 41.0 inches in a day and storm total of 87.5 inches. The ice inflicted severe damage to electric light, telephone and telegraph companies, fruits and ornamental trees. Many locations, earlier snow had not melted, resulting in substantial snow depths.
December 9 to 11, 1919	Statewide storm	One of three heaviest snowfall-producing storms to hit Oregon on record. Lowest statewide average temperature since record keeping began in 1890. The Columbia River froze over, closing the river to navigation from the confluence with the Willamette River upstream. Nearly every part of the state affected. Snow totals (inches): Albany 25.5, Bend 49.0, Cascade Locks 21.5,

		Eugene 8.5, Heppner 16.0, Parkdale 63.0, Pendleton 15.0, Siskiyou Summit 50.0
February 10, 1933	Statewide storm	Cold outbreak across state. The city of Seneca, in northeast Oregon, recorded the state's all-time record low temperature of -54 degrees F. The next day high was nearly 100 degrees warmer at 45 degrees).
January 31 to February 4, 1937	Statewide storm	. Heavy snowfalls in the western slopes of the Cascades and the Willamette Valley. Deep snowdrifts blocked major highways and most minor roads in northern Oregon and passes of the Cascade Mountains for several days.
Jan 5 - 7, 1942	Columbia, Clackamas, Multnomah, Washington, Marion, Linn, Yamhill, Polk counties	Considerable sleet, followed by freezing rain in some areas. Freezing rain, resulting in heavy accumulations of ice in upper and middle Willamette Valley. Roads and streets dangerous for travel, orchard and shade trees damaged, and telephone, telegraph, and power wires and poles broken down.
Mid Jan – Feb, 1950	Statewide storm	Extremely low temperatures injured a large number of orchard and ornamental trees and shrubs, and harmed many power and telephone lines and outdoor structures. Severe blizzard conditions and a heavy sleet and ice storm together caused several hundred thousand dollars damage and virtually halted traffic for two to three days. Columbia River Highway closed between Troutdale and The Dalles leaving large numbers of motorists stranded, removed to safety only by railway. Damage to orchard crops, timber, and power services, costing thousands in damages.
January 9 to 20, 1950	Columbia, Washington, Multnomah, Hood River, Wasco, Clackamas, Yamhill, Marion, Polk, Linn, Benton, Lane, counties	Frequent snowstorms throughout January. Snow heavier during this January than ever before on record. Snow plus high winds created widespread blowing and drifting of snow. Deep snowdrifts closed all highways west of the Cascades and through the Columbia River Gorge. Sleet 4-5 inches in northwestern Oregon. Sleet turned to freezing rain, creating havoc on highways, trees, and power lines. Hundreds of motorists stranded in the Columbia River Gorge, only rescued by train. Hundreds of thousands of dollars of damage occurred. Winds reached 60 – 70 mph in gusts along the coast and excess of 40 mph in Portland and Grants Pass. Outdoor work and school halted due to impeded traffic, down power lines, and community isolation. In Portland 32.9 inches of snow fell (5.8 inches was the January average).

Dec 5 – 7, 1950	Washington, Multnomah, Hood River, Wasco, Sherman, Gilliam, Morrow, Umatilla counties	Severe ice storm with light freezing rain over the Columbia Basin east of the Cascades. Heavy ice accretions on trees, highways, power and telephone lines causing accidents due to broken limbs, slippery pavements, and down power lines. Heavy snowfall across Oregon. Crater Lake reported 93 inches of snow for December.
Jan. 18, 1956	Washington, Multnomah, Hood River, Wasco, Sherman, Gilliam, Morrow, Umatilla counties	Freezing rain mixed with snow. Ice coated trees, highways and utility lines. Traffic accidents due to slick surfaces. Trees heavy with ice broke, sometimes on top of houses.
Jan 11 – 12, 1960	Columbia, Clackamas, Multnomah, Washington, Marion, Linn, Yamhill, Polk counties	Light to moderate snows and freezing rain produced dangerous highway conditions. Automobile accidents, but no known fatalities. Accidents blocked arterial highways creating serious traffic jams.
Jan 30 – 31, 1963	Columbia, Clackamas, Multnomah, Washington, Marion, Linn, Yamhill, Polk, Hood River, Waco, Jefferson, Deschutes counties	Substantial snowfall amplified by moderate to severe icing created hazardous conditions on highways. Power lines downed due to ice or felled trees. Injuries,1 reported death, and statewide school closures due to the icy streets and highways.
January 25 to 31, 1969	Douglas, Coos, Josephine, Jackson, Columbia, Clackamas, Multnomah, Washington, Marion, Linn, Yamhill, Polk counties	Snowfall records throughout Lane, Douglas, and Coos counties were surpassed by incredible numbers. 2-3 feet on the valley floors. Heavier amounts at higher elevations. At Eugene, a snow depth of 34 inches. Total January snowfall was 47 inches, nearly seven times the normal monthly snowfall. Roseburg reported 27 inches and monthly snowfall of 35.2 inches. Along the coast, where the average snowfall is generally less than two inches, January snowfall totals ranged2-3 feet, with snow depths of 10-20 inches reported. Hundreds of farm buildings and several large industrial buildings collapsed under the weight of the heavy wet snow. Heavy losses in livestock. Entire communities completely isolated for nearly a week. Traffic on major highways west of the Cascades and central Oregon halted. Total losses estimated $3 to $4 million.
Jan 17 – 19, 1970	Washington, Multnomah, Hood River, Wasco, Sherman, Gilliam, Morrow, Umatilla counties	Columbia River Basin area for a week. Ice accumulation up to 1.5 inches on tree branches. Property damages due to destroyed orchards and utilities.

Nov 22-23, 1970	Columbia, Washington, Multnomah, Hood River, Wasco, Clackamas, Yamhill, Marion, Polk, Linn, Benton, Lane, counties	Freezing rain across Western Oregon, especially in Corvallis, Albany, Salem, Independence, and Dallas. Ice accumulations up to .5 inches broke thousands of tree limbs and telephone lines. Hazardous traffic conditions, power and phone outages, and felled trees.
Feb 4 – 6, 1972	Columbia, Clackamas, Multnomah, Washington, Marion, Linn, Yamhill, Polk counties	Several days of sub-freezing temperatures across Oregon followed by warm moist air across northwestern Oregon. Glazed roads were hazardous. 140 persons in Portland treated for sprains, fractures or head injuries. Some ambulance services doing twice their normal business.
Jan 11 – 12, 1973	Columbia, Clackamas, Multnomah, Washington, Marion, Linn, Yamhill, Polk counties	Rains beginning in the Willamette Valley glazed streets and highways in the Portland area and into the Gorge. Auto, bus and truck accidents and persons injured in falls. Hospitals reported "full house" conditions. Glaze of .25 - .75 inches in the Portland area.
Jan. 1978	Columbia Gorge, Willamette Valley, Portland, OR and Vancouver, WA	Over an inch of rain froze, covering everything with ice. Power outages (some for more than 10 days). Areas east of Portland hit hardest.
Jan 9 – 10, 1979	Portland, Multnomah County, OR	Severe ice storm in Portland area as a Pacific storm moved across the state. Temperatures ranged from low teens to 33 degrees F. Half inch of rain turned to ice.
Jan. 5, 1986	Multnomah, Hood River, Waco counties	Roads covered with ice and caused power outages to several thousand houses.
February 1 to 8, 1989	Statewide storm	Heavy snow across state. Up to 6-12 inches of snow at the coast, 9 inches in Salem, more than a foot over the state. Numerous record temperatures set. Wind chill temperatures 30 - 60 degrees below zero F. Power failures throughout state, with home and business damage resulting from frozen plumbing. Several moored boats sank on the Columbia River because of ice accumulation. Five weather-related deaths (three auto accidents caused by ice and snow, and two women froze to death). Damage estimates exceeded one million dollars.
February 14 to 16, 1990	Columbia, Clackamas, Multnomah, Washington, Hood River, Wasco, Marion, Linn, Yamhill, Polk counties	24 to 35 inches of snow in Cascade Locks and Hood River. Up to 28 inches in the North Coast Range, 16 inches at Timberline Lodge. The Willamette Valley had 2-4 inches with up to 1 foot in higher hills around Portland. 10-15 inches of snow in the North Coast Range, 20-35 inches in the North Cascades,1-2 feet in the South Cascades. Snow in South-central areas included 9 inches at Chemult, 6-8 in Klamath Falls and Lakeview. 6 inches at Tipton Summit in the northeast mountains and Juntura in the southeast.

Jan. 6-7, 1991	All of Eastern Oregon	Constant precipitation all over Oregon. Freezing rain in Willamette Valley made transportation difficult. Two auto fatalities. 1-6 inches of new snow in high ground of eastern Oregon. 12 inches of snow in the Columbia Gorge.
Jan. 16-18, 1996	Columbia Gorge, Willamette Valley, Portland, OR Columbia, Clackamas, Multnomah, Washington, Hood River, Wasco, Marion, Linn, Yamhill, Polk counties	Freezing rain with heavy accumulations of glaze ice in the Gorge, Northern Cascades and extreme eastern Portland metropolitan area. Numerous minor traffic accidents due to power outages . Freezing rain in the Willamette Valley as far south as Eugene.
Feb. 2-4, 1996	Columbia Gorge, Willamette Valley, Portland, OR Columbia, Clackamas, Multnomah, Washington, Hood River, Wasco, Marion, Linn, Yamhill, Polk counties	Ice storm caused disruption of traffic and power outages in the Willamette Valley and Coast Range valleys. Freezing rain in the Willamette Valley. Traffic accidents, including a 100 car pileup near Salem. One traffic fatality near Lincoln City.
Dec. 26-30, 1996	Columbia Gorge, Willamette Valley, Portland, OR Columbia, Clackamas, Multnomah, Washington, Hood River, Wasco, Marion, Linn, Yamhill, Polk counties	Ice storm paralyzed the Portland metropolitan area and the Columbia Gorge. Ice accumulations of 4 - 5 inches in the Columbia Gorge. Interstate 84 through the Gorge closed for 4 days. Widespread electricity outages and hundreds of downed trees and power lines in the Portland area.
Dec.28, 2003-Jan. 9, 2004	Statewide storm	The most significant winter storm in several y ears brought snowfall to most of Oregon. The largest snowstorm to hit the Siskiyou Pass in Jackson County in a quarter century. Interstate 5 shut down for nearly a day as ODOT maintenance crews and Oregon State Police troopers dug stranded motorists out of snowdrifts reaching five to six feet. Two feet of snow in the Blue Mountains in eastern Oregon. Roadside snow levels exceeded six feet along the Tollgate Highway, Oregon 204. The eastbound lanes of Interstate 84 closed at Ladd Canyon east of La Grande. Additional segments of I-84 eastbound at Pendleton closed as stranded motorists filled truck stops, motels and restaurants in the La Grande area. Wet snow on highways in the Willamette Valley, toppled power lines and trees. Oregon 34 east of Philomath

		closed for 30 hours while crews removed trees. Snow on the Siskiyou Pass made national news and was a top story on the CNN website. 150 miles of I-5 from Ashland to south of Redding, California closed, leaving 100 to 200 vehicles stranded on the Siskiyou Pass overnight. The American Red Cross opened a shelter on the Southern Oregon University campus, and reports out of cities from Redding to Medford confirmed that all motels were full. Emergency service delivered gasoline, food, and water to stranded motorists and hard-to-reach areas. One fatality related to the storm. (Heart attack after helping a stranded motorist). I-5 North on the Siskiyou Pass closed for 19-hours. The snow event turned into a major ice storm. Icy roads made driving hazardous. Trees damaged or destroyed by ice adhering to the branches. Downed power lines, often due to falling trees, caused power outages. Businesses, school districts, and government offices closed or hours shortened. Several hundred flights cancelled at the Portland International Airport. Thousands of passengers stranded at the airport. The MAX light rail system also was shut down by the storm. ODOT closed Interstate 84 through the Columbia Gorge twice, for almost 70 hours total. Freight trucks and passenger cars had to detour over Mount Hood where, ironically, road conditions were better than they were in downtown Portland where all vehicles were required to chain up. ODOT closed US 101 over the Astoria Megler Bridge for about 14 hours as large chunks of ice fell off the bridge's superstructure. Many other highways in the state were closed. Freezing rain also in eastern Oregon. Minus thirty degrees reported in Meacham. 60 mph wind gusts in Union County created whiteout conditions, prompting the closure of I-84 between La Grande and Baker City. 2 fatalities. President Bush issued a major disaster declaration for 26 Oregon counties affected by the winter storm, later extended to 30 of Oregon's 36 counties. Estimated the cost of damages to public property at $16 million. A frigid arctic air mass, heavy snow, sleet and freezing rain, strong east winds and blizzard conditions through and near the Columbia River Gorge snarled travel, forced school and business closures, and resulted in widespread power outages and properly damage in

		Northwestern Oregon. 2-6 inches of snow along the North Oregon Coast, 2-8 inches in the Willamette Valley,5–8 inches in the Portland metro area, and up to 27 inches in the Cascade Mountains. Up to 2 inches of sleet and freezing rain followed the snowfall. In Portland this winter storm: limited or halted most forms of travel resulted in the cancellation of over 1300 flights at Portland International Airport, stranding 90,000 passengers. Shut down Portland's light rail train system. Closed most businesses and schools Blizzard conditions in the Columbia River Gorge: Closured Interstate 84 between Troutdale and Hood River. Closed Washington State Route 14 between Washougal, and White Salmon , Washington. Halted east-west travel through the Gorge and stranding hundreds of trucks at both ends of the Gorge. Weight from snow and ice buildup: Downed trees and power lines, leaving 46,000 customers without power, and collapsed roofs at Portland's Gunderson Steel and Rail, Fred Meyer stores in Gateway and Clackamas, and a barn in Forest Grove that killed 4 horses. Collapsed a Scappoose marina roof, sinking 4 boats and damaging many others. Snowfall in the Cascades ranged from 8 inches at Blue Box Pass and Bennett Pass to 27 inches at Timberline Lodge and White River.
March 8-10, 2006	Lane, Linn, Benton, Marion, Jefferson, Polk, Yamhill, Clackamas counties	Snow fell up to a few inches at the coast and through the Willamette Valley; 2 - 4 feet in the Coast Range, Cascades, and Cascade Foothills. Many school closures.
January 2 – February 9, 2008	Hood River, Waco, Sherman, Gilliam, Morrow, Umatilla, Union, Grant, Baker, Wheeler, Jefferson Deschutes, Crook	Heavy snow and freezing rain across eastern Oregon. 5-13 inches of snow. A multi-vehicle accident closed Interstate 84, 15 miles west of Arlington, for 5 hours. 36 Oregon National Guard personnel helped with snow removal in Detroit and Idanha with over 12 feet of record snow. Inmate crews removed snow that cracked walls

	counties	and collapsed roofs
December 9-11, 2009	Marion, Linn, Lane counties	Freezing rain covered the central valley with a coating of ice. South of Salem, numerous road closures due to accidents caused by icy roadways. Interstate 84 from Troutdale to Hood River closed for 22 hours.
November 29-30, 2010	Hood River, Multnomah, Wasco counties	4-5 inches of snow reported in Cascade Locks and Hood River. 1/2 inch of ice in Corbett.
January 12-18, 2012	Hood River, Wasco counties	4.5 inches of new snow reported in Hood River. Interstate 84 closed due to ice and snow east of Troutdale.

Source: The National Weather Service

Figure 2-WS-4: Rescuing snow bound vehicles, Old Oregon Trail Highway between Kamela and Meacham, 1923.

Source: ODOT

Figure 2-WS-5: Stranded motorists on Interstate 5 southbound at Siskiyou Pass, late December 2003; note vehicles being towed out the "wrong way".

Source: ODOT

Figure WS-7: Trees collapse from weight of the snow on Oregon 62 near Prospect, February 2, 2008.

Source: ODOT

Figure 2-WS-6:Detroit, February 2, 2008, buried from the 12 feet of snow.

Source: ODOT

Probability

Winter storms occur annually in Oregon bringing snow to Oregon's mountains and much of Eastern Oregon. These winter storms are welcomed by Oregon's skiers and the ski industry and are tolerated by people traveling the numerous mountain passes and Eastern Oregon highways kept open during the winter by the Oregon Department of Transportation. Approximately every four years, winter storms bring extreme cold temperatures, snow, sleet and ice to Oregon's western valley floors. Because these storms are infrequent and tend to last only a few days, residents in Western Oregon are often unprepared for such events.

One issue concerns the fact that there is not a statewide effort regarding Winter Storm impacts, either historical or for future planning. There are only limited snow fall sensors distributed mainly through the mountain ranges of the state and there is not an annual tracking system in place for snow fall statewide. A program of statewide snow fall sensors would allow us to better understand the impact of Winter Storms on Oregon and have a better means of predicting potential impacts in the future.

The American Society of Civil Engineers has developed a 50-year recurrence interval map of Oregon showing probabilities for ice thickness caused by freezing rain (ASCE-7-02, 2003a), found at website: http://www.americanlifelinesalliance.com/pdf/PipecommFinalPosted061705.pdf

According to the Northwest Weather and Avalanche Center (NWAC), experts on the subject aren't able to predict, nor do they completely understand each and every avalanche occurrence. Regional avalanche centers across the country do have the technology to forecast avalanche danger. These forecasts are valuable tools in reducing danger to people. However, no matter what forecasts indicate even the smallest avalanche can be injurious or life threatening!

Avalanche danger ratings levels have been adopted within North America (with slight changes in Canada) and are generally accepted internationally. These levels are:

Low Avalanche Danger (green)—Natural avalanches very unlikely. Human triggered avalanches unlikely. Generally stable snow. Isolated areas of instability. Travel is generally safe. Normal caution advised.

Moderate Avalanche Danger (yellow)—Natural avalanches unlikely. Human triggered avalanches possible. Unstable slabs possible on steep terrain. Use caution in steeper terrain on certain aspects.

Considerable Avalanche Danger (orange)—Natural avalanches possible. Human triggered avalanches probable. Unstable slabs probable on steep terrain. Be increasingly cautious in steeper terrain.

High Avalanche Danger (red)—Natural and human triggered avalanches likely. Unstable slabs likely on a variety of aspects and slope angles. Travel in avalanche terrain is not recommended. Safest travel on windward ridges of lower angle slopes without steeper terrain above.

Extreme Avalanche Danger (red with black border)—Widespread natural or human triggered avalanches certain. Extremely unstable slabs certain on most aspects and slope angles. Large destructive avalanches possible. Travel in avalanche terrain should be avoided and travel confined to low angle terrain well away from avalanche path run outs.

Oregon Vulnerabilities

Overview

Requirement: 44 CFR §201.4(c)(2)(ii): Th[e] risk assessment shall include… (ii) (a)n overview and analysis of the State's vulnerability to the hazards described . . . based on estimates provided in local risk assessments as well as the State risk assessment. The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events…

The vulnerability assessment provides an overview and analysis of the state's vulnerabilities to each of Oregon's 11 hazards addressed in this Plan. Both local and state risk assessments are referenced to identify vulnerabilities, most vulnerable jurisdictions and potential impacts from each hazard. In addition, a side-by-side comparison of local and state vulnerability "rankings" for each county show similarities and differences that the state will be addressing over the course of the next Plan update cycle.

Requirement: 44 CFR §201.4(c)(2)(ii): Th[e] risk assessment shall include… (ii) (s)tate owned or operated critical facilities located in the identified hazard areas shall also be addressed.

Requirement: 44 CFR §201.4(c)(2)(iii): Th[e] risk assessment shall include… (iii) (a)n overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State shall estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.

The exposure analysis and estimate of potential losses to state owned and leased facilities and critical and essential facilities (both state owned/leased and non-state owned/leased) located within hazard zones performed by the Department of Geology and Mineral Industries (DOGAMI) for the 2012 Oregon NHMP was updated by DOGAMI in 2014. Loss data is not available in local plans. Therefore, this Plan only includes the most recent estimates provided by DOGAMI.

In addition, an overview of seismic lifeline vulnerabilities is a new addition to the 2015 Oregon NHMP. This includes a summary of the Oregon Department of Transportation's (ODOT's) 2012 Oregon Seismic Lifeline Report (OSLR) findings, including identification of system vulnerabilities, loss estimates and recommended next steps. Both the facilities and lifeline report findings are further discussed in the Regional Risk Assessment later in this Plan (pg.xx-xx).

Local Vulnerability Assessments

Requirement: 44 CFR §201.4(c)(2)(ii): Th[e] risk assessment shall include… (ii) (a)n overview and analysis of the State's vulnerability to the hazards described . . . based on estimates provided in local risk assessments …. The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events…

The Oregon Military Department, Office of Emergency Management (OEM) periodically collects perceived hazard vulnerability information from each of the 36 counties in the state. The information is generated at the local government level to meet OEM required activities under the State's Emergency Management Grant Program (EMPG) and to inform Local NHMPs. To assess vulnerability, each community follows the OEM Hazard Analysis Methodology.

The OEM Hazard Analysis Methodology was first developed by FEMA in 1983, and has been gradually refined by OEM over the years. There are two key components to this methodology: vulnerability and probability. Vulnerability examines both typical and maximum credible events, and probability reflects how physical changes in the jurisdiction and scientific research modify the historical record for each hazard.

This analysis is conducted by county or city emergency program managers, usually with the assistance of a team of local public safety officials. The assessment team initially identifies which hazards are relevant in that community. Then, the team scores each hazard in four categories: history, probability, vulnerability, and maximum treat. Following is the definition and ranking method for each category:

- History= the record of previous occurrences
  - Low 0 - 1 event past 100 years
  - Moderate 2 - 3 events past100 years
  - High 4 + events past100 years
- Probability= the likelihood of future occurrence within a specified period of time
  - Low one incident likely within 75 to 100 years
  - Moderate one incident likely within 35 to 75 years
  - High one incident likely within 10 to 35 years
- Vulnerability= the percentage of population and property likely to be affected under an "average" occurrence of the hazard
  - Low < 1% affected
  - Moderate 1 - 10% affected
  - High > 10% affected
- Maximum Threat= the highest percentage of population and property that could be impacted under a worst-case scenario
  - Low < 5% affected
  - Moderate 5 - 25% affected
  - High > 25% affected

Each county in Oregon is required to periodically update their Hazard Analysis. As part of this analysis, each county develops risk scores for the natural hazards that affect their communities. These scores range from 24 (low) to 240 (high), and reflect risk for each particular hazard, as determined by a team process facilitated by the emergency manager. This method provides local jurisdictions with a sense of hazard priorities, or relative risk. It doesn't predict the occurrence of a particular hazard in a community, but it does "quantify" the risk of one hazard compared with another. By doing this analysis, local planning can first be focused where the risk is greatest. This analysis is also intended to provide comparison of the same hazard across various local jurisdictions.

Among other things, the hazard analysis can:

- Help establish priorities for planning, capability development, and hazard mitigation;
- Serve as a tool in the identification of hazard mitigation measures;
- Be one tool in conducting a hazard-based needs analysis;
- Serve to educate the public and public officials about hazards and vulnerabilities; and
- Help communities make objective judgments about acceptable risk.

Although this methodology is consistent statewide, the reported raw scores for each county are based on partially subjective rankings for each hazard. Because the rankings are used to describe the 'relative risk' of a hazard within a county, and because each county conducted the analysis with a different team of people working with slightly different assumptions, comparing scores between counties must therefore be treated with caution.

For the purposes of the Oregon NHMP, the State Vulnerability Assessment focuses only on county vulnerability rankings (H, M, L) taken from LNHMP Hazard Analysis scores. These rankings provide the state an understanding of local hazard concerns and priorities. Table 2-V-1 presents locally perceived vulnerability for each of Oregon's 11 primary hazards by county. In the Regional Risk Assessment, found later in this Plan (beginning on pg. x), both county vulnerability and probability rankings are identified for each OEM Natural Mitigation Region.

Source: Oregon Emergency Management (OEM) Hazard Analysis Methodology, OEM, May 2008

Table 2-V-1: Local Vulnerability Rankings by County

Local Vulnerability Rankings by County											
County	Coastal Erosion	Tsunami	Drought	Dust Storm	Earthquake	Volcanic	Landslide	Wildfire	Flood	Wind Storm	Winter Storm
Baker			H	M	M	L	M	H	M	H	H
Benton			L		H	L	L	M	M	M	M
Clackamas			L		H	H	L	M	M	L	M
Clatsop	H	H	M		H	M	H	H	H	H	H
Columbia			M		H	H	M	M	M	H	H
Coos	M	H	M		H	M	M	M	H	H	H
Crook			H	L	L	H	L	M	H	M	M
Curry		H			H	H	L	H	H	H	
Deschutes			L		M	H		M	L	L	H
Douglas - Central					M		M	H	H	M	H
Douglas - Coastal	L	H			H		M	M	M	M	M
Gilliam			H		M	M	M	M	M	L	H
Grant			H		M	L	M	H	H		H
Harney			M					M	M	L	M
Hood River			H		M	L	M	M	M	H	H
Jackson			M		H	L	L	M	M	H	H
Jefferson			H		L	H	L	H	M		H
Josephine					H			M	M	H	H
Klamath			M		M	L		L	M		M
Lake			H		H	H	L	M	M	M	H
Lane - Central			M		M	M	L	M	H	M	H
Lane - Coastal		H			H		M	L	H	H	L
Lincoln		M	L		M	L		M	L	H	
Linn					H	H		M	H	M	H
Malheur			H	L	M	M	M	M	H	M	M
Marion					H	M		M	M	H	H
Morrow				M	H		M	M	H	M	H
Multnomah					H	H	M	M	H	H	H
Polk					H	M		M	H	H	
Sherman			M		L	L	M	M	M	M	M
Tillamook		H	L	L	H	M	H	H	H	H	H
Umatilla					M			M	M	H	H
Union			M	M	M		M	M	M	H	H
Wallowa			H		M	L	M	H	H	H	H
Wasco			H		M	L	M	M	L	H	H
Washington			M		H	H	L	M	H	H	H
Wheeler					M			H	M		H
Yamhill			H		H		M	L	H	M	H

Vulnerability Scores:
H= high
M= moderate
L= low

Source: OEM, November 2013

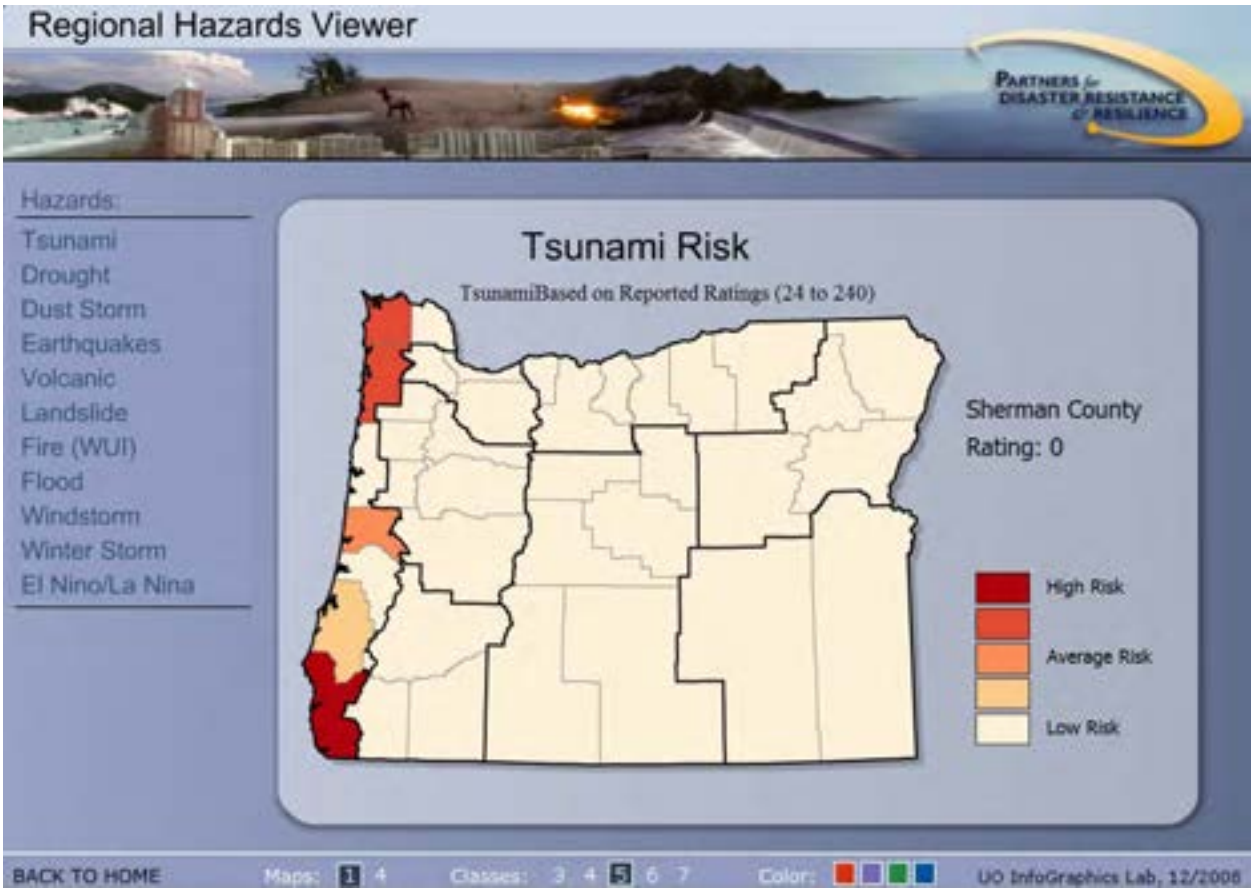
State's Natural Hazards Viewer

The State's Natural Hazards Viewer is an online interface that visually describes natural hazard risk throughout the State of Oregon. Information displayed in the Viewer is taken from the OEM Hazard Analysis Methodology findings. Figure 2-V-1 shows an example of the visual display available for each hazard. By moving the cursor over each county, individual hazard scores are displayed on the right-hand side of the screen. Up to four hazard maps can be displayed at one time. The Natural Hazard Viewer can be found at the following web link:
http://infographics.uoregon.edu/hazardmaps/webapp/beta.html

Data in the Natural Hazards Viewer is current through December 2008. However, OEM is requiring counties to update their analyses for the local fiscal year that ends on June 30, 2016. Therefore, the Hazards Viewer will be updated to reflect these county updates during the summer of 2016.

Note: the Natural Hazards Viewer addresses all hazards in the plan except Coastal Erosion.

Figure 2-V-1: The State's Natural Hazard Viewer



Source: UO InfoGraphics Lab, website: http://infographics.uoregon.edu/hazardmaps/webapp/beta.html

State Vulnerability Assessment

Requirement: 44 CFR §201.4(c)(2)(ii): Th[e] risk assessment shall include… (ii) (a)n overview and analysis of the State's vulnerability to the hazards described . . . based on estimates provided in … the State risk assessment. The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events…

Oregon does not have one standard method to assess risk across all hazards statewide. For each of the 11 hazards addressed in this Plan, a state agency has been identified as the lead over that hazard (Table 2-V-2). All hazards have at least one lead and one support hazard expert who have compiled and analyzed respective hazard data for this state risk assessment. In some instances both experts are from the same agency. For other hazards two agencies worked together to perform the analysis. Due to the wide range of data available for each hazard, the method used to assess risk varies from hazard to hazard. For example, there is a wealth of data available to assess risk to earthquakes, but data on dust is difficult to locate. In response, the state relies on hazard lead and support experts to determine the best method, or combination of methods, to identify vulnerability and potential impacts for this Plan. In general, each hazard is assessed using a combination of exposure, historical, and scenario analyses. Hazards for which more data exists have undergone a more robust analysis, including earthquake, flood, tsunami, and wildfire; and to a lesser degree Volcanic events (primarily related to Mt. Hood).

Table 2-V-2: Oregon NHMP Hazard Lead Agencies

Hazard	Lead Agency	Support Agency
Coastal Hazards	Department of Geology and Mineral Industries	
Drought	Oregon Water Resources Department	
Dust	Oregon Office of Emergency Management	Oregon Department of Transportation
Earthquake	Oregon Office of Emergency Management	Department of Geology and Mineral Industries
Flood	Department of Land Conservation and Development	
Landslide	Department of Geology and Mineral Industries	Department of Geology and Mineral Industries
Tsunami	Department of Geology and Mineral Industries	
Volcano	Department of Geology and Mineral Industries	
Wildfire	Oregon Department of Forestry	
Windstorm	Oregon Public Utility Commission	Oregon Climate Change Resource Institute
Winter Storm	Oregon Department of Transportation	Oregon Public Utility Commission

Coastal Hazards

Chronic hazards are clearly evident along Oregon's shores, including beach, dune, and bluff erosion, landslides, slumps, gradual weathering of sea cliffs, and flooding of low-lying coastal lands during major storms. The damage caused by chronic hazards is usually gradual and cumulative. The regional, oceanic, and climatic environments that result in intense winter storms determine the severity of chronic hazards along the coast. These hazards threaten property in its path and, in extreme events, can threaten human life as well.

Most Vulnerable Communities

The Department of Geology and Mineral Industries is the agency with primary oversight of the coastal erosion hazard. Based on agency staff review of the available hazard data, DOGAMI ranks Tillamook, Lincoln, Clatsop and Curry Counties one through four respectively as the counties most vulnerable to coastal erosion in the state.

Coastal hazards in Coos, Lane and Douglas counties are considered to be generally negligible. This is because the bulk of these coastlines have little population base and hence are largely unmodified. In Coos County, coastal hazards can be found in a few discrete communities such as adjacent to the Coquille jetty in Bandon and along Lighthouse Beach near Cape Arago. Similarly, coastal hazards in Lane County are confined almost entirely to the Heceta Beach community and adjacent to the Siuslaw River mouth, particularly within the lower estuary mouth where development lines coastal bluffs that is gradually being eroded by riverine processes.

The most vulnerable counties and communities on the Oregon coast include:

Tillamook County (ranked #1)
- Neskowin (erosion and flooding)
- Pacific City (erosion)
- Tierra del Mar (erosion and flooding)
- Cape Meares (flooding)
- Twin Rocks (erosion and flooding)
- Rockaway Beach(erosion and flooding)

Lincoln County (ranked #2)
- Yachats to Alsea Spit (erosion)
- Waldport (erosion and flooding)
- Alsea Spit (erosion)
- Seal Rock (erosion and landsliding)
- Ona Beach to Southbeach (erosion and landsliding)
- Newport (landsliding)
- Beverly Beach (erosion and landsliding)
- Gleneden Beach to Siletz Spit (erosion, landsliding, and flooding)
- Lincoln City (erosion and landsliding)

Clatsop County (ranked #3)

- Falcon Cove (erosion and landsliding)
- Arch Cape (erosion and flooding)
- Tolovana to Cannon Beach (erosion and flooding)
- Seaside (Flooding)

Curry County (ranked #4)

- Nesika Beach (erosion and landsliding)
- Port Orford (flooding at Garrison Lake)

Coos County (ranked #5)

- North Coos Spit (erosion)
- Lighthouse Beach (bluff erosion)
- Bandon (erosion and flooding, particularly adjacent to the south Coquille jetty)

Lane County (ranked #6)

- Heceta Beach (erosion and flooding)

Intellectual knowledge derived from field experience, discussions with scientists, scientific publications, agency reports, and thesis dissertations were used to determine which communities are the most vulnerable to coastal hazards within Oregon.

Drought

There is a tendency to associate drought conditions with the arid sections of the state, principally east of the Cascade Mountains. However, this perception is not entirely accurate. During the winter of 2002-03, Coos and Curry counties on the south coast experienced drought conditions for some time.

When a drought occurs, it may affect all regions of the state. However, most of Oregon's urban areas usually fare much better during a drought than rural, less populated regions of the state. By encouraging or invoking water conservation measures during a drought, municipalities can reduce residential and industrial demand for water.

Rural areas are much more dependent on water for irrigation for agricultural production. Several regions of the state, dependent on an agricultural economy, are more vulnerable to drought conditions. Generally, counties west of the Cascades and in the southern portions of the state are more prone to drought-related impacts.

Most Vulnerable Communities

The Water Resources Department (WRD) is the state agency with primary oversight of drought conditions and mitigation activities. Based on the frequency of drought declarations issued by the Governor issued since 1995, Klamath and Baker Counties are the most vulnerable to drought, followed by Sherman, Gilliam, Morrow, and Malheur Counties. Both Klamath and Baker Counties have experienced 7 drought declarations out of the last 13 years.

The above communities were identified as most vulnerable based on the frequency of drought declarations issued by the Governor issued since 1995.

Dust Storms

Dust storms primarily occur in the arid regions of Central and Eastern Oregon They are generally produced by the interaction of strong winds, fine-grained surface material, and landscapes with little vegetation. The winds involved can be as small as "dust devils" or as large as fast moving regional air masses.

Most Vulnerable Communities

Based on research conducted by OEM, the counties in Oregon most vulnerable to dust storms are Morrow and Umatilla. These two counties are most vulnerable because historically in locations close to their county lines, a combination of soil types, past agricultural practices, and high winds have led to motor vehicle accidents that have resulted in many deaths and injuries. The following counties are also vulnerable: Baker, Deschutes, Harney, Jefferson, Klamath, Lake, Malheur, Union, and Wasco.

Poor visibility leading to motor vehicle crashes is the worst potential impact of these storms; often these crashes result in fatalities and major injuries. Other impacts include poor air quality, including dust infiltration of equipment and engines, loss of productive soil, and an increase in fine sediment loading of creeks and rivers.

Communities most vulnerable to dust storms have been identified on the basis of historic occurrence, including the impacts of those occurrences.

Earthquake

Oregon has a long history of earthquakes (and tsunamis, which often accompany major off-shore seismic events) because of the state's proximity to the Cascadia Subduction Zone (CSZ) just off the Pacific Coast, and also from crustal faults that run under or near populated areas. Oregon is vulnerable to damage because of its topography and geology; many of its local soil profiles are prone to liquefaction during the shaking that would occur during a Cascadia event. Depending on the size of the fault rupture, areas receiving major damage from an magnitude 8.0 – 9.0 earthquake would include most of the counties in Western Oregon; the heavily populated metropolitan areas of Portland, Salem, and Eugene would certainly experience major damage.

A major Cascadia earthquake (>M_W8.5) or a local crustal earthquake (>M_W5.0) would be devastating to the Portland metropolitan area. The Northern Willamette Valley/Portland Metro Region is the most densely populated region with a total population of almost 1.5 million people. A major earthquake would likely do extensive damage to many of the region's 1382 bridges and overpasses as few bridges have been retrofitted to withstand this type of event. In addition, many structures are located on soils likely to experience liquefaction from the shaking that would occur. Most of the state's major critical infrastructure such as energy sector lifelines, transportation hubs, and medical facilities are particularly vulnerable to damage from liquefaction and long periods of shaking. The Northern Willamette Valley/Portland Metro Region also has 49 dams that could be affected by a major earthquake.

Depending on the size of the fault rupture, this magnitude of earthquake would likely cause extensive damage to structures and infrastructure in the Mid/Southern Willamette Valley Region as well. The city of Salem, Oregon's state capital, is only 46 miles south of Portland. To gain a perspective of the potential damage from a major earthquake, 169 of the state's facilities are located in or near Salem. To replace these state facilities would cost over $850 million dollars. Marion County, where Salem is located, has over 20 dams and 400 bridges that could also be affected. For more information on state facilities located in earthquake hazard zones, see pg. X of this Plan.

The long-term effects from a major earthquake would be felt for years. Major damage would likely occur to most of western Oregon's public and private buildings, its vast road network, to its rail lines and power transmission lines, and to the state's most important employment centers.

A major earthquake that occurs in the southern, central, or eastern areas of Oregon would be catastrophic to that region. It may also be catastrophic to the state economically if key facilities and infrastructure (i.e., highways, bridges, rail lines, power transmission lines, and dams) are damaged to the degree that links with the Portland metropolitan region and the rest of the state could not quickly be repaired. However, the length of time for the state to recover from such a disaster occurring in an area away from the Portland metropolitan area should be much shorter than if the same event occurred near Portland. For more information about the seismic vulnerability lifelines, see pages X-X summarizing the Oregon Department of Transportation's Seismic Lifeline Report.

In the late 1990s, DOGAMI developed two earthquake loss models for Oregon: (1) a magnitude 8.5 Cascadia Subduction Zone (CSZ), and (2) a 500-yr probabilistic ground motion model, which combines CSZ, intraplate and crustal events. Both models are based on HAZUS, a computer program developed by the Federal Emergency Management Agency (FEMA) as a means of determining potential losses from earthquakes. The CSZ event is based on a potential 8.5 earthquake generated off the Oregon

coast. The 500-yr model incorporates earthquake ground motions with 10% chance of exceedence in the next 50 years, which was used by the building code. It does not look at a single earthquake (as in the CSZ model) but encompasses many faults.

Neither model takes into account damage and losses from unreinforced masonry buildings or tsunamis. Due to the limitations of HAZUS with respect to modeling damage from unreinforced masonry buildings and tsunamis at that time, DOGAMI estimated fatalities outside of the HAZUS model. DOGAMI developed lower bound estimates on the order of 5,000 fatalities.

DOGAMI investigators caution that the models contain a high degree of uncertainty and should be used only for general planning and policy purposes. Despite the model limitations, valuable estimates of damage, functionality and relationships between county estimates are made available for each region within Oregon. Results for each OEM Hazard Mitigation Region are found in the Regional Risk Assessment section of this plan (beginning on page xx).

In 2000, DOGAMI co-organized an important conference convening scientists to discuss the Cascadia fault. At this Geological Society of America Penrose conference, which was held in Seaside, Oregon, there was scientific consensus that the most recent Cascadia earthquake occurred in 1700, that it was a magnitude 9 earthquake, and the Cascadia fault would produce future magnitude 9 earthquakes and damaging tsunamis (DOGAMI Special Paper 33, found at website: http://www.naturenw.org/qs3/products.php?sku=001227).

Also in 2000, the Oregon Seismic Safety Policy Advisory Commission (OSSPAC) developed a report called "Oregon At Risk" which address the many cross-cutting effects that earthquakes have on our communities, including the basic services provided by infrastructure. Five objectives were outlined: 1) earthquake awareness and education, 2) earthquake risk information, 3) earthquake safety of buildings and lifelines, 4) geoscience and technical information, and 5) emergency pre-disaster planning, response and recovery. The report is available on the following Oregon Emergency Management webpage: http://www.oregon.gov/omd/oem/pages/osspac/osspac.aspx.

In 2007, DOGAMI completed a rapid visual screening (RVS) of educational and emergency facilities in communities across Oregon, as directed by the Oregon Legislature in Senate Bill 2 (2005). RVS is a technique developed by the Federal Emergency Management Agency (FEMA), known as FEMA 154, to identify, inventory, and rank buildings that are potentially vulnerable to seismic events. DOGAMI surveyed a total of 3,349 buildings, giving each a 'low,' 'moderate,' 'high,' or 'very high' potential of collapse in the event of an earthquake. It is important to note that these rankings represent a probability of collapse based on limited observed and analytical data and are therefore *approximate* rankings.[1] The RVS study can help to prioritize which buildings require additional studies and which do not. To fully assess a building's potential of collapse, a more detailed engineering study completed by a qualified professional is required. In the Regional Assessments section of this Plan, details of this study for each OEM Hazard Mitigation Region can be found (pages xx-yy).

[1] State of Oregon Department of Geologic and Mineral Industries, Implementation of 2005 Senate Bill 2 Relating to Public Safety, Seismic Safety and Seismic Rehabilitation of Public Building, May 22, 2007, iv.

In 2012 the USGS published Professional Paper 1661-F, by Goldfinger and others[2], "Turbidite Event History Methods and Implications for Holocene Paleoseismicity of the Cascadia Subduction Zone" which provides the most comprehensive catalog of prehisotirc Cascadia Subduction earthquakes to date, including a 10,000 year chronology (Table 2-V-EQ-1) of as many as 40 subduction earthquakes ranging from ~M8.1 to ~M9.3. This study forms the basis for efforts to evaluate the consequences and likelihood of future Cascadia earthquakes, and has been particularly useful in DOGAMI's program to map tsunami inundation zones along the Oregon coast.

Turbidite number	Mean age	Northern margin following interval, in years	Northern margin slip from following time, in meters	Southern margin interval, in years	Southern margin slip from time, in meters	Average northern and southern slip, in meters	Segment name	Rupture length, in kilometers	Rupture width, in kilometers	Mw	Seismic moment
1	250					16.0	A	1,000	83	9.00	398.4E+27
2	482	232	8.9	232	8.3	8.4	A	1,000	55	8.70	138.3E+27
2a	550			57	2.1	2.1	D	222	40	8.19	23.8E+27
3	798	305	11.2	248	8.9	10.0	A	1,000	83	8.87	250.2E+27
3a	1,077			279	10.0	10.0	C	444	50	8.34	40.1E+27
4	1,243	446	16.3	167	6.0	11.2	A	1,000	83	8.90	277.9E+27
4a	1,429			186	6.7	6.7	C	444	50	8.25	29.9E+27
5	1,554	311	11.4	125	4.5	7.9	A	1,000	83	8.80	197.4E+27
5a	1,820			266	9.6	9.6	C	444	50	8.41	51.9E+27
5b	2,036			216	7.8	7.8	B	660	60	8.66	122.5E+27
5c	2,323			286	10.3	10.3	C	444	50	8.41	51.1E+27
6	2,536	982	35.9	213	7.7	21.8	A	1,000	83	9.09	542.7E+27
6a	2,730			194	7.0	7.0	D	222	40	8.24	28.7E+27
7	3,028	492	18.0	298	10.7	14.4	A	1,000	83	8.97	358.2E+27
7a	3,157			129	4.6	4.6	D	222	40	8.23	27.5E+27
8	3,443	415	15.2	286	10.3	12.7	A	1,000	83	8.94	317.2E+27
8a	3,599			442	5.6	0.0	B	660	60	8.67	124.4E+27
8b	3,890			447	10.5	10.5	D	222	40	8.15	21.0E+27
9	4,108	665	24.4	218	7.9	16.1	A	1,000	83	9.01	401.1E+27
9a	4,438			548	11.9	0.0	B	660	60	8.35	41.4E+27
9b	4,535			426	3.5	3.5	D	222	40	8.17	22.5E+27
10	4,770	661	24.2	235	8.5	16.3	A	1,000	83	9.01	406.6E+27
10a	5,062			292	10.5	10.5	C	444	50	8.39	47.6E+27
10b	5,260			198	7.1	7.1	B	660	60	8.43	55.7E+27
10c	5,390			130	4.7	4.7	C	444	50	8.55	82.7E+27
10d	5,735			344	12.4	12.4	C	444	50	7.90	9.0E+27
10f	5,772			37	1.3	1.3	C	444	50	8.37	44.8E+27
11	5,959	1189	43.5	187	6.7	25.1	A	1,000	83	9.13	625.5E+27
12	6,466	508	18.6	508	18.3	18.4	A	1,000	55	8.93	304.0E+27
12a	6,903			437	15.7	15.7	D	222	40	8.22	26.7E+27
13	7,182	715	26.2	278	10.0	18.1	A	1,000	83	9.04	450.7E+27
14*	7,625	443	16.2	443	16.0	16.1	A	1,000	83	9.01	400.7E+27
14a	7,943			318	11.4	11.4	D	222	40	8.17	22.1E+27
15	8,173	548	20.1	230	8.3	14.2	A	1,000	83	8.97	353.0E+27
15a	8,459			286	10.3	10.3	D	222	40	8.36	42.9E+27
16	8,906	733	26.8	447	16.1	21.4	A	1,000	83	9.09	534.1E+27
16a	9,074			169	6.1	6.1	D	222	40	7.54	2.6E+27
17	9,101	195	7.2	27	1.0	4.1	A	1,000	55	8.49	67.0E+27
17a	9,218	117	4.3	117	4.2	4.2	A	1,000	55	8.50	70.1E+27
18	9,795	577	21.1	577	20.8	20.9	A	1,000	83	9.08	521.2E+27

Table 2-V-EQ-1: Turbidite Event History Methods and Implications for Holocene Paleoseismicity of the Cascadia Subduction Zone

Source: Goldfinger and others, 2012

[2] Goldfinger, C. , Nelson, C.H., Morey, A.E., Johnson, J.E., Patton, J.R., Karabanov, E., Gutierrez-Pastor, J., Eriksson, A.T., Gracia, E., Dunhill, G., Enkin, R.J., Dallimore, A., and Vallier, T., 2012. Turbidite Event History__Methods and Implications for Holocene Paleoseismicity of the Cascadia Subduction Zone; USGS Professional Paper 1661-F

In 2013, DOGAMI published Open-File Report O-13-09, by Wang and others[3], "Earthquake Risk Study for Oregon's Critical Energy Infrastructure Hub**".** This report highlights the concentration of critical energy facilities in the Portland Harbor area of the lower Willamette River, and the seismic risk posed by a combination of liquefiable soils and the age and poor condition of many facilities in the area. The report also points out how dependent Oregon is on this concentration of facilities for virtually all petroleum products used in the State, and the potential impacts on post earthquake recovery if these facilities are damaged.

Also in 2013, the Cascadia Region Earthquake Workgroup (CREW) issued a Cascadia magnitude 9 scenario, which provides a narrative on the expected effects throughout the region including northern California, Oregon, Washington and British Columbia (www.crew.org). Some of the CREW scenario was obtained from the 2011 Federal Emergency Management Agency (FEMA) regional planning scenario for the Pacific Northwest (Draft Analytical Baseline Study for the Cascadia Earthquake and Tsunami, September 12, 2011) based on a magnitude 9 megathrust earthquake. Using the most current version of HAZUS, FEMA's disaster loss modeling software, they have prepared the most comprehensive and realistic Cascadia scenario to date). In addition to HAZUS analysis, FEMA evaluated likely tsunami effects for several Oregon coastal communities. Data like this provides a critical tool for planning emergency response and for designing a resiliency plan, as it highlights areas of infrastructure damage that affect the entire system. State and local government agencies have been working with FEMA to provide local knowledge to inform the scenario, and the final document and associated databases should be adopted as the basis for planning. In general the scenario results predict severe damage in coastal areas, particularly in tsunami inundation zones with widespread but moderate damage along the I-5 corridor (Figure 2-V-EQ-1). For more information about tsunamis in Oregon, see pages 102 and X. For more information about seismic lifeline vulnerability see page xx.

[3] Wang, Y., Bartlett, S.F., and Miles, S.B., 2013, Earthquake Risk Study for Oregon's Critical Energy Infrastructure Hub; Oregon Department of Geology and Mineral Industries Open-File Report, O-13-09

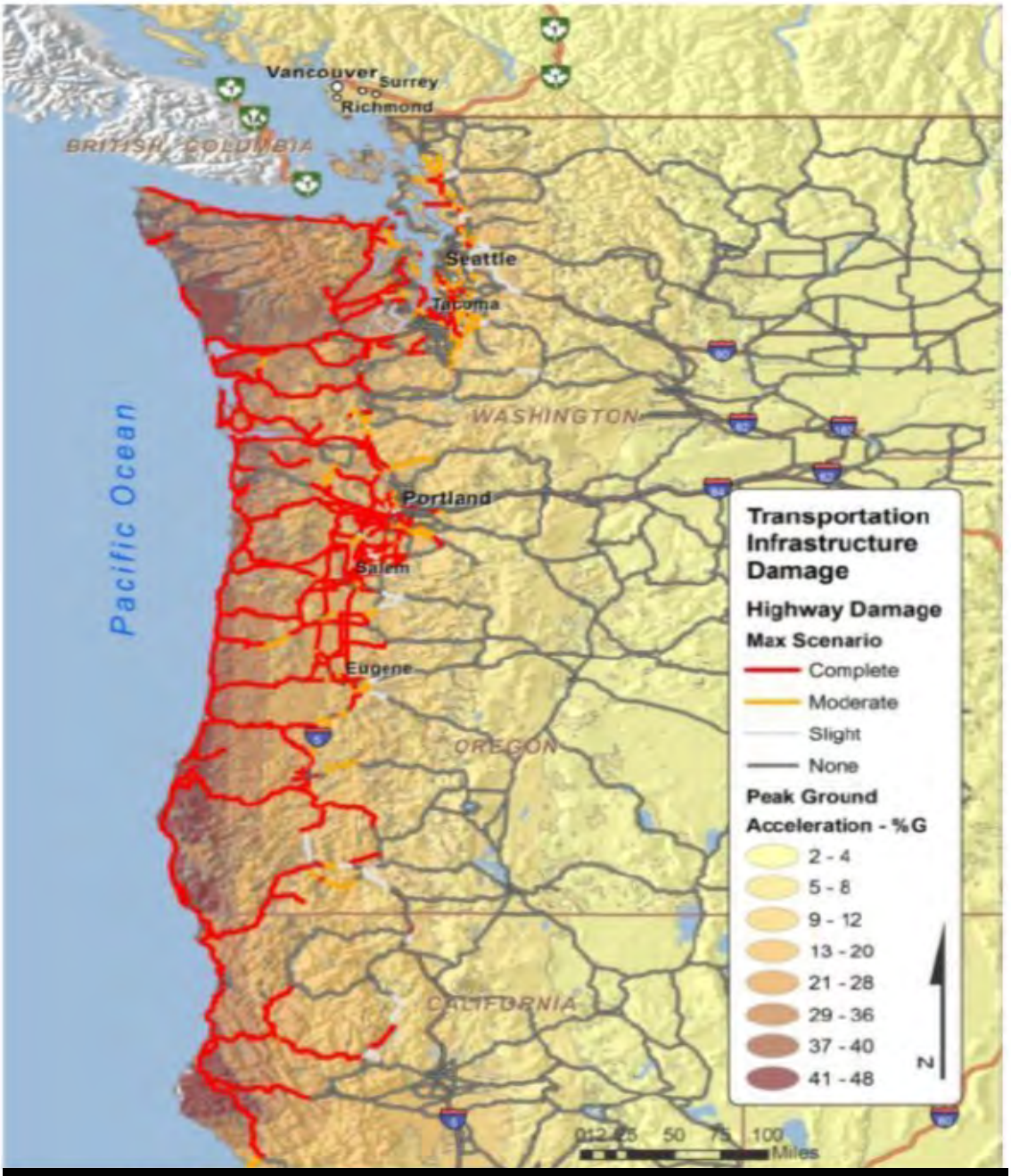


Figure 2-V-EQ-1: Draft HAZUS results from the 2011 FEMA Analytical Baseline Study for the Cascadia Earthquake and Tsunami

Source: FEMA

The Oregon Seismic Safety Policy Advisory Commission (OSSPAC) developed a report in 2013 entitled "The Oregon Resilience Plan: Reducing Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami". The report, which was commissioned by a legislative resolution, estimated the impacts of an M 9.0 Cascadia subduction earthquake on the State's population, buildings and infrastructure with a focus on 7 sectors:

- Businesses
- Coastal Communities
- Energy
- Transportation
- Communication
- Critical Buildings
- Water and wastewater

For each of these sectors the Plan sets a desired level of performance (time to recover a given level of service) and estimates preformance under current conditions in each of four earthquake impact zones:

- Tsunami, where damage will be complete and saving lives through evacuation is the main focus
- Coastal, where damage will be severe and the focus will be on managing a displaced population with little functioning infrastructure,
- Valley, where moderate damage will be widespread, and the focus will be on restoring services quickly to re-start the economy,
- Eastern, where damage will be light, and the focus will be on staging recovery efforts for the rest of the state.

For the first three zones, times for restoration of services(Table 2-V-EQ-2) are typically several months, and in some cases several years, a clearly unacceptable level of performance, and far short of the general performance goal of two weeks to restore most services to functional, if not original conditions. These results are particularly sobering in the face of the report's finding that where services are not restored within 2 to 4 weeks, businesses will either fail or leave.

The report includes extensive recommendations for actions that if implemented over the next 50 years, should greatly improve the performance of Oregon's buildigns and infrastructure in the next great earthquake. These include:

- Undertaking comprehensive assessments of key structures and systems
- Launching a sustained program of investment in retrofit of Oregon's public buildings
- Creating a package of incentives to help Oregon's private sector improve its resieinece
- Updating public policies to streamline recovery and to increase public preparedness.

Upon consideration of the Plan, the 2013 Oregon Legislature passed legislation establishing an Oregon Resilience Task Force to facilitate a comprehensive and robust plan to implement the Oregon Resilience Plan. The Task Force will report to the Oregon Legislature during the 2015 session.

The report and an executive summary are available at:

- http://www.oregon.gov/OMD/OEM/osspac/docs/Oregon_Resilience_Plan_Final.pdf
- http://www.oregon.gov/OMD/OEM/osspac/docs/Oregon_Resilience_Plan_Executive_Summary_Final.pdf

Table 2-V-EQ-2: Estimated Times for Restoration Services post CSZ and tsunami event

Critical Service	Zone	Estimated Time to Restore Service
Electricity	Valley	1 to 3 months
Electricity	Coast	3 to 6 months
Police and fire stations	Valley	2 to 4 months
Drinking water and sewer	Valley	1 month to 1 year
Drinking water and sewer	Coast	1 to 3 years
Top-priority highways (partial restoration)	Valley	6 to 12 months
Healthcare facilities	Valley	18 months
Healthcare facilities	Coast	3 years

Source: Oregon Resilience Plan, OSSPAC, 2013.

Most Vulnerable Communities

The Department of Geology and Mineral Industries (DOGAMI) is the agency with primary oversight of the earthquake hazard identification and risk evaluation, and also has responsibilities on earthquake risk mitigation. DOGAMI has developed two earthquake loss models for Oregon based on the two most likely sources of seismic events: (1) the Cascadia Subduction Zone (CSZ), and (2) combined crustal events (500-year Model). Both models are based on HAZUS, a computerized program, currently used by the FEMA as a means of determining potential losses from earthquakes.

The CSZ event is based on a potential 8.5 earthquake generated off the Oregon coast. The model does not take into account a tsunami, which probably would develop from the event. The 500-Year crustal model does not look at a single earthquake (as in the CSZ model); it encompasses many faults, each with a 10% chance of producing an earthquake in the next 50 years. The model assumes that each fault will produce a single "average" earthquake during this time. Neither model takes unreinforced masonry buildings into consideration

DOGAMI investigators caution that the models contain a high degree of uncertainty and should be used only for general planning purposes. Despite their limitations, the models do provide some approximate estimates of damage.

Below DOGAMI lists all counties in the state in the order of projected losses and damages (highest to lowest) based on the two models mentioned above. See Special Paper 29 for more information on these earthquake loss models, found at website:
http://www.naturenw.org/qs3/products.php?sku=001223.

Counties listed from highest to lowest based on projected losses and damages from a Cascadia Subduction Zone (CSZ) earthquake:

1. Multnomah
2. Lane
3. Coos
4. Washington
5. Marion
6. Benton
7. Lincoln
8. Josephine
9. Clatsop
10. Jackson
11. Linn
12. Curry
13. Clackamas
14. Douglas
15. Yamhill
16. Polk
17. Tillamook
18. Columbia

19. Klamath
20. Deschutes
21. Hood River
22. Jefferson
23. Grant
24. Gilliam
25. Harney
26. Lake
27. Umatilla
28. Baker
29. Crook
30. Malheur
31. Morrow
32. Sherman
33. Union
34. Wallowa
35. Wasco
36. Wheeler

Counties listed from highest to lowest based on projected losses and damages due to combined crustal events using a 500-year model:

1. Multnomah
2. Washington
3. Lane
4. Marion
5. Clackamas
6. Coos
7. Jackson
8. Benton
9. Linn
10. Klamath
11. Josephine
12. Lincoln
13. Clatsop
14. Yamhill
15. Douglas
16. Polk
17. Curry
18. Tillamook
19. Columbia
20. Deschutes

21. Umatilla
22. Hood River
23. Malheur
24. Lake
25. Wasco
26. Jefferson
27. Baker
28. Morrow
29. Union
30. Wallowa
31. Crook
32. Grant
33. Harney
34. Sherman
35. Wheeler
36. Gilliam

It should be emphasized that in the original 1999 DOGAMI study, the estimated statewide losses did not include tsunami-related losses. In the future, an updated HAZUS study should include the current population and infrastructure as well as losses from a tsunami. If the tsunami losses were included, the above 15 counties may be shifted to include coastal counties, such as Lincoln County.

Flood

Flooding is a natural phenomenon. Damage and loss of life occur when flood waters come into contact with the built environment or where people congregate. Flood can have secondary effects of causing streambank erosion and channel migration, or precipitating landslides. Every Oregon County has suffered flood losses at one time or another. Some counties are more susceptible to both flood events and damages.

Most Vulnerable Communities

The Department of Land Conservation and Development (DLCD) compiled data from NOAA's Storm Events Database and from the FEMA National Flood Insurance Program to develop a flood damage vulnerability index by county. Statistics data were calculated and aggregated statewide for the period 1978 through 2013 for five input datasets: number of events, structure and crop damage estimates in dollars, and NFIP claims number and dollar amounts. The mean and standard deviation were calculated for each input. Then, each county was assigned a score ranging from 0 to 3 for each of these inputs according to Table 2-V-FL-1.

Table 2-V-FL-1: Scoring Scheme for Flood Vulnerability Index

Score	Description
3	DataCounty data point is greater than 2.5 times standard deviation for the input dataset
2	DataCounty data point is greater than 1.5 times standard deviation for the input dataset
1	DataCounty data point is within standard deviation
0	No data reported

DLCD summed the scores across for each of the five inputs to create a statewide county-by-county vulnerability index. Since there were five input datasets, with a maximum score of 3 each, the maximum countywide score could be 15. The theoretical minimum score could be 0, but in fact all but one county had complete datasets, so the actual minimum score was 4.

A vulnerability index value over 5 indicates that one or more input variables exceeded 1.5 times the confidence limit for that input, meaning that the value exceeds the average value for that input. A score over 6 indicates that at least one variable significantly exceeds average values. Coos, Clackamas, Columba, Curry, and Tillamook Counties all received scores exceeding 6.

Tillamook, Clackamas, and Columbia Counties received scores of 11, 9 and 8 respectively indicating that two or more input variables significantly exceeded average values for the State, making these the counties in Oregon most vulnerable to flood losses. Figure 2-V-FL-1 shows results overlaid onto annual rainfall amounts to convey the relationship between rainfall amounts and flood vulnerability. Public land areas were removed to show distribution of potential damages to the built environment, although analyses were conducted countywide. Not surprisingly, areas of, or downstream from, areas of high annual rainfall also tend to be most vulnerable to flood damage. This appears to more true in the northern rather than southern Oregon coast, possibly due to higher population density in the north.

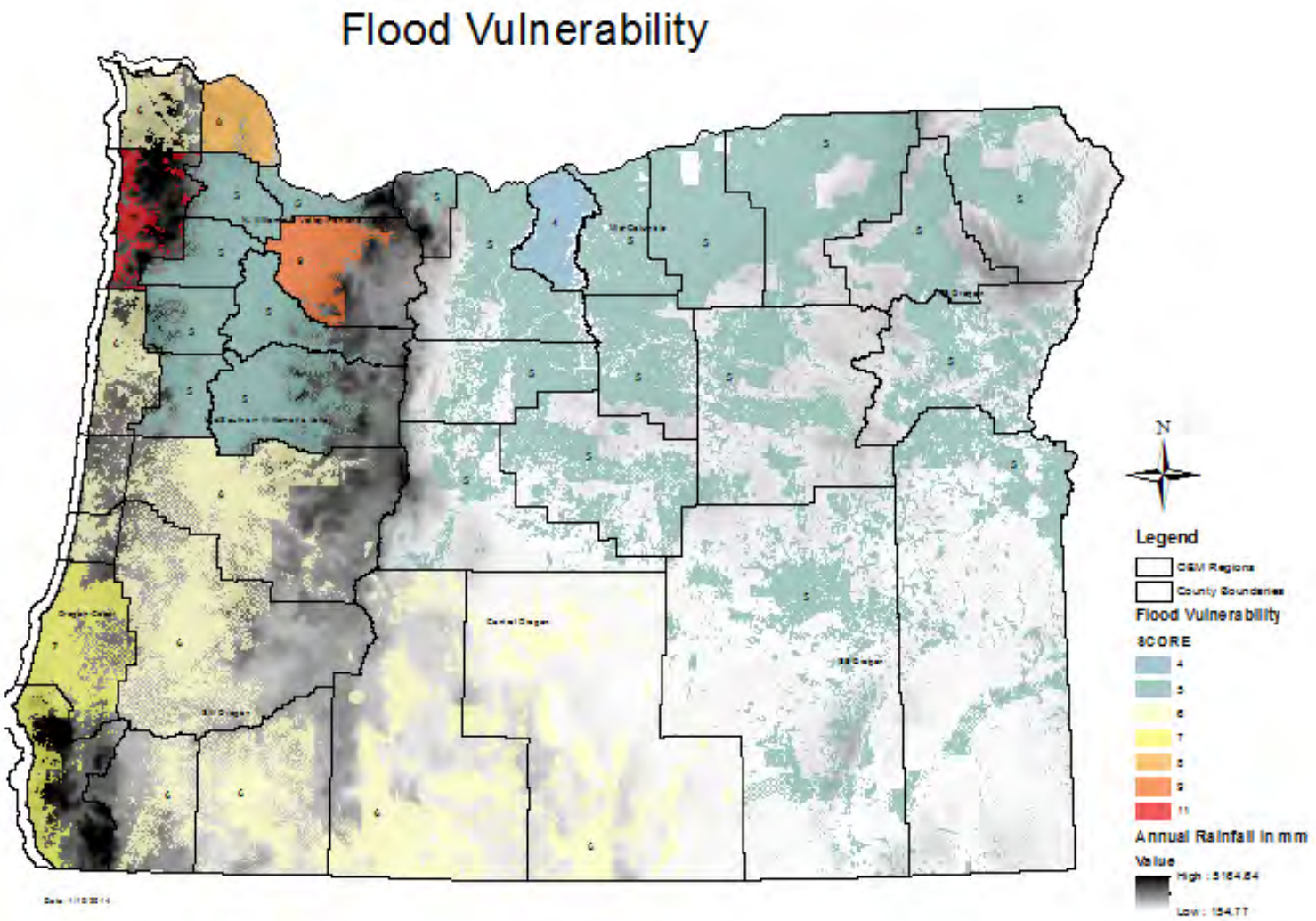


Figure 2-V-FL-1: Annual Rainfall Relationship to Flood Vulnerability

Source: DLCD

DLCD supplemented the countywide assessment of vulnerability by looking at cities that received the most NFIP claims by dollar amount and count. DLCD also identified cities with a large proportion of their land identified as Special Flood Hazard Area (SFHA). Eight of the 10 cities with highest NFIP paid claims and number of claims are within the three most vulnerable counties (Clackamas, Columbia, and Tillamook).

Table 2-V-FL-2: Top 10 Cities Susceptible to Flooding, Measured by Paid NFIP Flood Insurance Claims

City	County **boldface = most vulnerable county**	NFIP Claims Paid ($)	Population	$ Per Capita
VERNONIA	**Columbia**	$13,733,794	2080	6603
TILLAMOOK	**Tillamook**	$7,551,192	4880	1547
LAKE OSWEGO	Multnomah/ **Clackamas**	$3,583,026	36760	97
SALEM	Marion	$3,390,250	156455	22
PORTLAND	Multnomah/ **Clackamas**	$2,581,748	586307	4
MILWAUKIE	**Clackamas**	$1,904,200	20435	93
WEST LINN	**Clackamas**	$1,886,683	25370	74
OREGON CITY	**Clackamas**	$1,467,600	32500	45
TUALATIN	Washington/ **Clackamas**	$1,390,381	26120	53
COOS BAY	Coos	$1,355,071	16060	84

Table 2-V-FL-3: Top 10 Cities Susceptible to Flooding, Measured by Number of NFIP Paid Claims

City	County	Number of NFIP Paid Claims	Population	% Per Capita
VERNONIA	**Columbia**	223	2080	11%
PORTLAND	Multnomah/ **Clackamas**	198	586307	<1%
SALEM	Marion	190	156455	<1%
TILLAMOOK	**Tillamook**	180	4880	1%
LAKE OSWEGO	**Clackamas**	64	36760	<1%
MILWAUKIE	**Clackamas**	57	20435	<1%
SHERIDAN	Yamhill	57	6180	<1%
COOS BAY, CITY OF	Coos	56	16060	<1%
LINCOLN CITY, CITY OF	Lincoln	53	7965	1%
WEST LINN, CITY OF	**Clackamas**	52	25370	<1%

Cities with a high proportion of FEMA-defined Special Flood Hazard area within their city boundaries are shown in Table 2-V-FL-4. The area of Special Flood Hazard Area within city limits for each NFIP city was estimated by calculating the area of the Special Flood Hazard Area minus the area below the ordinary high water line. This was compared to the city limit area. In Oregon we can assume that highest population densities are in cities due to state requirement to site most residential development inside Urban Growth Boundaries. All of the cities identified in this analysis have small populations, however, and therefore don't help point to identify a significant proportion of the population at risk from flooding. Only one of these cities is located in one of the three most vulnerable counties.

Table 2-V-FL-4: Top 10 Cities by Percent Land Area in 1% Annual Flood Zone

City	County	Percent Land Area Within 1% Flood Zone	Population Portland State University, 2012 Annual Population Report Tables
Helix	Umatilla	70	190
Scio	Linn	62	830
Burns	Harney	52	2835
Warrenton	Clatsop	47	5090
Seaside	Clatsop	38	6550
Vernonia	Columbia	36	2080
Sheridan	Yamhill	36	6180
Ione	Morrow	34	330
Adams	Umatilla	33	365
Athena	Umatilla	33	1125

Source: DLCD (2012)
Estimated using area of Special Flood Hazard Area, excluding area below ordinary high water divided by area within city limits.

Severe Repetitive Losses

Oregon is fortunate to have few residential severe repetitive loss properties (Table 2-V-FL-5). Four of the 11 buildings FEMA identified as Severe Repetitive Loss (SRL) properties are located in one of the counties identified as most vulnerable to flood frequency, with the exception of damage.

In 2013, DLCD visited each of the FEMA-identified severe repetitive loss properties and assessed their mitigation potential. Contact has been made with the owners of homes located in Lane and Marion Counties, and one in Clackamas County. The building in Tillamook County appears to have already been mitigated. The home in Lincoln County (was) elevated in 2014.

Table 2-V-FL-5: Distribution of Severe Repetitive Flood Loss Properties by County

County	Severe RFL Properties
Clackamas	3
Clatsop	1
Lane	1
Lincoln	2
Marion	2
Tillamook	1
Washington	1

Source: FEMA

Channel Migration

Channel migration vulnerability is not well understood at the state or regional level because no systematic identification of the hazard has been performed in Oregon.

Landslide

Landslides occur statewide in Oregon, although areas with steeper slopes, weaker geology, and higher annual precipitation tend to have more landslides. In general, the coast and Coast Range Mountains and the Cascade Mountains have the most landslides. On occasion, major landslides occur on US or State Highways that sever these major transportation routes (including rail lines) causing temporary but significant economic damage to the state. Although less frequent, landslides and debris flows do occur that result in the death of people located in their paths.

Most Vulnerable Communities

The Department of Geology and Mineral Industries is the agency with primary oversight of the landslide hazard. Based on agency staff review of available hazard data, DOGAMI lists Clackamas, Linn, Douglas, Coos, Lane, Tillamook, Multnomah, Benton, Jackson, Clatsop, Lincoln, Marion, Washington, Curry, Columbia, Hood River, and Yamhill Counties as having the highest hazard and risk to landslide in the state. Because of their importance to the state's economy, landslides occurring in Multnomah, Clackamas, and Washington Counties present the greatest danger from this type of disaster. Landslides that close US Highway 101 or any of the many highways connecting the I-5 corridor to the coast have a significant effect on commerce in the Oregon Coast Region.

Currently, there is no method to evaluate statewide vulnerability to landslides. The communities listed above are primarily based on existing landslide inventory data in SLIDO-2. DOGAMI has performed landslide risk analysis of some individual communities in Oregon including Astoria, part of the HWY 30 transportation corridor, the Mt. Hood region, and parts of the Portland metro. The Mt Hood multi-hazard risk study provides details on the methods used to evaluate landslide and other hazard risk.

Burns, W.J., Hughes, K. B., Olson, K. V., McClaughry, J. D., Mickelson, K. A., Coe, D. E., English, J.T., Roberts, J. T., Lyles Smith, R. R., Madin, I.P., 2012. Multi-Hazard and Risk Study for the Mount Hood Region, Multnomah, Clackamas, and Hood River Counties, Oregon, Oregon Department of Geology and Mineral Industries, Open-File Report O-11-16

Tsunami

The entire coastal zone is highly vulnerable to tsunami impact. Distant tsunamis caused by earthquakes on the Pacific Rim strike the Oregon coast frequently but only a few of them have caused significant damage or loss of life. Local tsunamis caused by earthquakes on the Cascadia Subduction Zone (CSZ) happen much less frequently but will cause catastrophic damage and, without effective mitigation actions, great loss of life.

Because tsunamis in Oregon typically occur as a result of earthquakes, the unknown time and magnitude of such events adds to the difficulty in adequately preparing for such disasters. If a major earthquake occurs along the CSZ, a local tsunami could follow within 5 to 30 minutes. Although tsunami evacuation routes have been posted all along the Oregon Coast, damage to bridges and roadways from an earthquake could make evacuation quite difficult even if a tsunami warning were given. In addition, if a major earthquake and tsunami occur during the "tourist season," causalities and fatalities from these disasters would be far greater than if the same events occurred during the winter months.

It is also important to consider where the impact of a tsunami would be the greatest. Owing to relatively large resident and visitor populations located at very low elevations, cities facing the Pacific Ocean on the northern Oregon Coast are more vulnerable to inundation and have the greater potential for loss of life than coastal cities in central and southern Oregon. USGS estimated vulnerable populations using a tsunami inundation zone similar to the Medium CSZ event, which is the most likely event to occur. That study found that:

> (1) 22,201 residents and 10,201 households are in the zone, with the largest numbers in the northern coast;
>
> (2) the City of Seaside had the highest number of residents in the zone (4,790), (3) 7,912 residents (36% of all residents in the zone) are in unincorporated communities, the balance in 26 incorporated communities.[4]

Similar inventories are not yet available for the currently mapped DOGAMI tsunami inundaton zones, but the lower probability L, XL, and XXL CSZ inundation zones will impact more residents. Distant tsunamis, except for the most extreme events, will not affect significant numbers of residents, since they flood principally beaches and immediate waterfront areas. Loss of life from distant tsunamis will also be far less than for local tsunamis, because there will be at least four hours to evacuate prior to wave arrival rather than 15-20 minutes.

That said, visitors are more vulnerable than residents to both distant and locally generated tsunamis, because they are more likely to be at beaches and shoreline parks and are generally less aware of hazard response and preparedness. During the summer and holidays, visitors can greatly outnumber residents in the small coastal towns. While intensive education and outreach programs led by DOGAMI and OEM have greatly increased awareness and preparedness, residents are much more likely to have received this education than visitors.

[4] US Geological Survey Scientific Investigations Report 2007-5283.

The Oregon Resilience Plan (ORP) uses the impact of a "Medium" or "M" CSZ earthquake and tsunami for planning purposes, because this was judged the most likely CSZ event (see DOGAMI Special Paper 43 for explanation). The current regulatory tsunami inundation utilized by the Oregon Building Code to limit new construction of critical, essential, large occupancy, and hazardous facilities also uses a scenario similar to the "Medium" case. The ORP describes the "M" impact as follows:

> *Following the Cascadia event, the coastal communities will be cut off from the rest of the state and from each other. The coastal area's transportation system, electrical power transmission and distribution grid, and natural gas service will be fragmented and offline, with long-term setbacks to water and wastewater services. Reliable communications will be similarly affected. Because so many of these connecting systems are single lines with little or no redundancy, any break or damage requiring repair or replacement will compromise the service capacity of the entire line.*
>
> *The loss of roads and bridges that run north and south will make travel up and down the coast and into the valley difficult, if not impossible, due to the lack of alternate routes in many areas. Reestablishing the roads and utility infrastructure will be a challenge, and the difficulties will be exacerbated in the tsunami inundation area by its more complete destruction. Even businesses outside of the tsunami inundation may not recover from the likely collapse of a tourist-based economy during the phased and complicated recovery and reconstruction period.*
>
> *Based on the resilience targets provided by the Transportation, Energy, Communications, and Water/Wastewater task groups, current timelines for the restoration of services up to 90-percen toperational levels will take a minimum of one to three years, and often over three years in the earthquake-only zone. Restoration in the tsunami zone will take even longer than that... The most critical infrastructure is the road and highway system. Without functioning road systems, none of the infrastructure can be accessed to begin repairs.*
>
> *The tsunami will also create an enormous amount of debris that needs to be gathered, sorted, and managed. The recent experience of Japan, with a similar mountainous coastline, has shown that debris management competes with shelter and reconstruction needs for the same flat land that is often in the inundation zone.*

The ORP estimates that times for recovery of the coastal infrastructure for a Medium CSZ event will be as follows: Electricity and natural gas – 3-6 months, drinking water and sewer systems –1-3 years, and Healthcare facilities – 3 years. The ORP gives no estimate for times to recover police and fire stations or the coastal transportation system, but times for the latter would no doubt be measured in years. Economic recovery would also be many years, since much of the coast is dependent on tourism that is directly dependent on the transportation system. According to the ORP:

> *Even if a business had sufficient capital to relocate, it is unlikely that the tourist industry will recover rapidly enough to support business start-up. Local authorities may need to keep tourists out of the inundation zones, for safety reasons, for months or years after a tsunami.*

Most Vulnerable Communities

The entire coastal region is highly vulnerable to tsunamis, but some areas are more vulnerable owing to geographic and demographic factors. Oregon Emergency Management (OEM) is the agency with primary oversight of emergency response to the tsunami hazard. A 1990 revision of DOGAMI's enabling statutes added geologic hazard mitigation to its responsibilities, but other state agencies such as OEM and local governments share this responsibility. Based on agency staff review of the available hazard data, particularly estimates of Wood (2007) [5], OEM lists, Clatsop and Tillamook counties as having the highest hazard to tsunami in the state. As previously mentioned, Seaside is the most vulnerable town to tsunamis on the coast, but Gearhart, Cannon Beach, Rockaway Beach, Pacific City, Neskowin, Salishan Spit, Cutler City in Lincoln City, South Beach in Newport, and downtown Waldport are all extremely difficult to evacuate owing to local geographic factors (marshes or lakes limiting evacuation, long distances to evacuation routes, and limited high ground for evacuees) and significant percentages of retirees with limited mobility.

Vulnerability of communities is based primarily on difficulty of evacuation in the 15-20 minutes between a CSZ earthquake and arrival of the tsunami. A community is considered highly vulnerable if the population is large with high ground located a long distance away accessible by only a few routes that could be compromised by earthquake damage.

Volcano

Oregon's vulnerability to volcanic events varies statewide. The Cascade Mountains, which separate Western Oregon from Central Oregon, poses the greatest threat for volcanic activity. OEM Hazard Mitigation Regions that include the Cascade Mountains are most vulnerable to the effects of a volcanic event. Within the State of Oregon, there are several volcanoes that may pose a threat of future eruption. These include Mount Hood, which most recently erupted about 200 years ago, Newberry Volcano with recent eruptions about 1300 years ago, and the Three Sisters and Mount Jefferson with eruptions about 15,000 years ago. Eruptions from volcanoes in Washington State, like the Mount St. Helens eruption in 1980, can also significantly impact Oregon.

Most Vulnerable Communities

The Oregon Department of Geology and Mineral Industries (DOGAMI) is the agency with primary oversight of the Volcano hazard. Based on agency staff review of the available hazard data, DOGAMI lists Clackamas, Douglas, Deschutes, Hood River, Jackson, Jefferson, Klamath, Lane, Linn, Marion, Multnomah and Wasco counties as having the highest volcanic hazard in the state. Deschutes County is most vulnerable in the Central Oregon Region because the region's most populous city, Bend, is located here and the greatest numbers of "composite" volcanic mountains are located near the county's population centers. Klamath and Jefferson counties are also vulnerable within this region. Other regions are also vulnerable to damage from volcanic eruptions. If Mount Hood erupted, the Northern Willamette Valley/Portland Metro Region and the Mid-Columbia Region would both be impacted. Because of Mount Hood's proximity to Portland, the Columbia River, the I-84 freeway, and major dams on the Columbia River, the potential for a large disaster exists.

Little has been done to evaluate risk to volcanoes. One of the first studies to evaluate risk for the Mount Hood region was by Burns and others (2011)(Figures 2-V-V-1 and 2-V-V-2; and Table 2-V-V-3). The main purpose of this study was to help communities on or near Mount Hood become more resilient to geologic hazards by providing accurate, detailed, and up-to-date information about the hazards and the community assets at risk. A second purpose was to explore hazard and risk analysis methodologies that would be applicable to other volcanic areas. The study examined volcano, landslide, flood, channel migration, and earthquake hazards on Mount Hood, along Highway 26 and the Sandy River Corridor, and along Highway 35 and the Hood River Corridor (Figure 2-V-V-1). Two types of risk analysis were performed: 1) hazard and asset exposure, and 2) HAZUS-MH (FEMA, 2005). The figure and table below are a summary of volcano and community asset exposure for the study area.

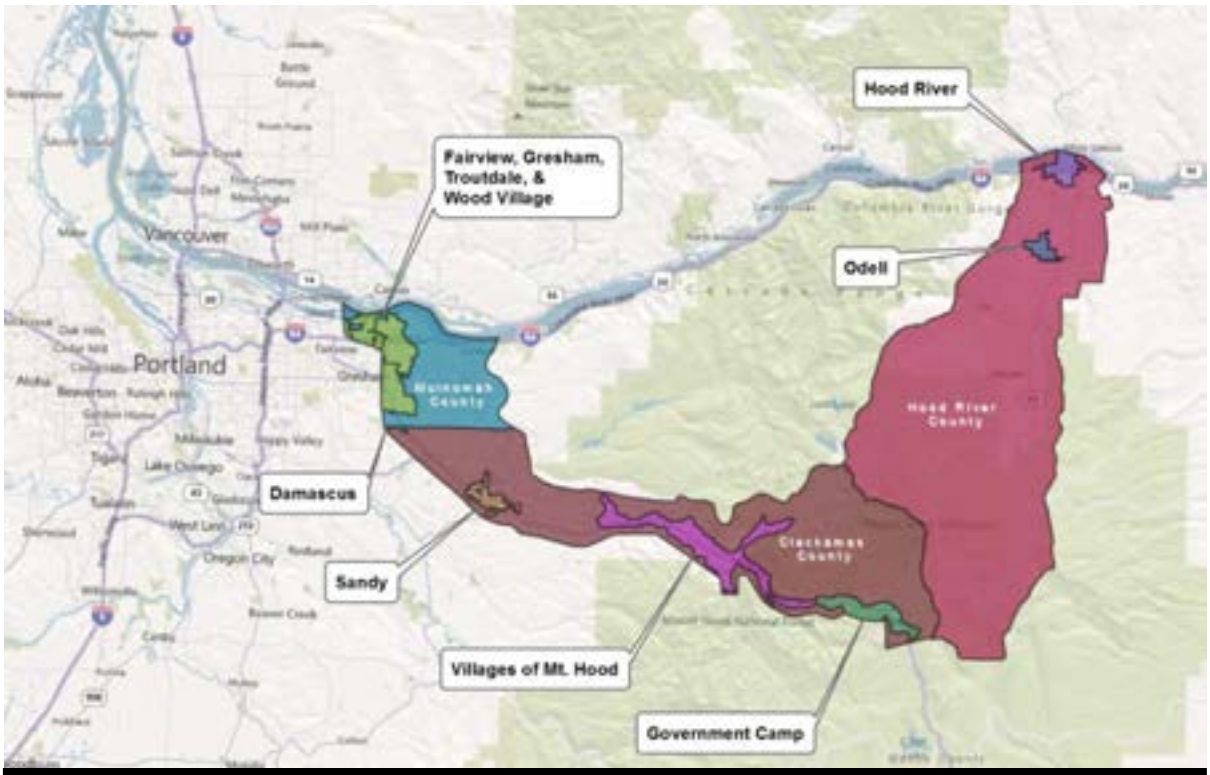


Figure 2-V-V-1: Mount Hood risk study project area.

Source: DOGAMI

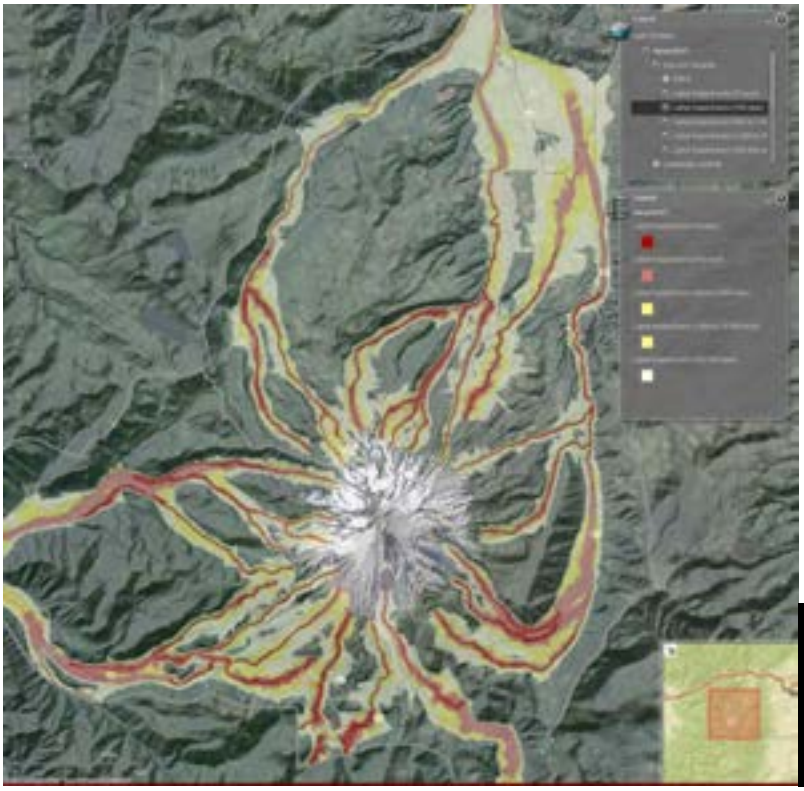


Figure 2-V-V-2: Interactive web map for Mount Hood risk study.

Source: DOGAMI. Map found at website: http://www.regongeology.org/MtHood/

This study also found approximately 5,000 people are located in the 500-year volcano hazard zones, which is a large amount of people to evacuate in an event. Although the report estimated 6% to 22% of the total study area community assets will be damaged or lost, this percentage is significantly more within some individual communities, especially The Villages at Mt Hood. Both risk methods resulted in ranges of percent damage and losses that appear reasonable. For example, we found 11% to 34% loss ratios for the volcano exposure method and 5% to 35% loss ratios for the HAZUS-MH volcano analyses are all in the same approximate range of 10% to 35%. The report estimates the loss ratio for the 500-year volcano hazard to be approximately 18% for the study area from these ranges of percent loss from the various portions of the two risk analyses.

Table 2-V-V-1: Summary of Community Asset Exposure to Volcano Hazards for Mount Hood

	Population	Buildings (Building Count/$Value)	Generalized Land Use/ Zoning Parcels (Count/$Value)	Critical Facilities	Primary Infrastructure – Roads (miles)
Proximal	2129	1,604 / $242 million	2,995 / $208 million	8	287
Lahar 10-year	163	120 / $32 million	520 / $19 million	0	22
Lahar 100-year	473	531 / $92 million	1,633 / $71 million	0	91
Lahar 500- to 10,000-year	3,843	3,731 / $663 million	7,120 / $402 million	7	271
Lahar 100,000-year	14,635	9,897 / $1,510 million	13,082 / $1,364 million	21	525

Source: DOGAMI, Burns and others, 2011

Wildfire

Wildfires are a common and widespread natural hazard in Oregon. Fire is a critical component of the forest and rangeland ecosystems found in all portions of the state. Over 41 million acres of forest and rangeland in Oregon are susceptible to wildfire, which may occur during any month of the year, but usually occur between July and October. In addition to wildland-urban interface(WUI) fires, Oregon experiences wildland fires that do not threaten structures, and also occasionally has prescribed fires. The principal type of wildfire affecting Oregon communities is the interface fire, which occurs where wildland and developed areas intermingle with both vegetation and structures combining to provide fuel. As more people have moved into WUI areas, the number of large wildfires impacting homes has escalated dramatically.

Most Vulnerable Communities

In 2006, the Oregon Department of Forestry conducted a Statewide Forest Assessment of the communities at risk to wildfire to determine priorities for delivering landowner assistance. The parameters of this assessment included high priority fish and wildlife habitat, potential for forest conversion, and communities at risk to wildfire. The communities at risk to wildfire component will be used to characterize the wildfire hazard in this Plan.

A community was defined as a geographic area within and surrounding permanent dwellings with basic infrastructure and services, under a common fire protection jurisdiction, government, or tribal trust or allotment, for which there is a significant threat due to wildfire. The 2006 communities at risk assessment first evaluated landscape wildfire risk based on ignition risk, fuel loading and hazard, suppression capability, and values at risk (population, municipal watersheds, commercial timber); and then evaluated community risk as a function of the surrounding landscape risk ratings.

Of the 595 identified community areas in Oregon, 159 (27%) face a HIGH risk from wildfire and 331 (56%) faced a moderate threat. Although the majority of OEM Hazard Mitigation Regions in Oregon have at least one high risk community, the majority are concentrated in Regions 4 and 6. In Region 4, Douglas County had the highest *absolute* number of high risk communities with 33, and Jackson County had the highest percent of communities facing high risk (all 22 identified communities). In Region 6, Deschutes County recorded the second highest percentage with 10 out of 12 identified communities facing high risk of wildfire.

An update to the 2006 statewide wildfire assessment is currently underway. The update is a part of a regional wildfire assessment referred to as the West Wide Risk Assessment (WWRA) to assess wildfire risk in 17 western states. The WWRA uses indices (Fire Risk, Fire Threat, Fire Effects) as well as Ratings (Values Impacted, Suppression Difficulty) to generate a composite assessment of wildfire vulnerability and risk. Although the WWRA is complete, Oregon is in the process of scaling the assessment to the state level, so the complete data set for Oregon is not available at this time. A complete wildfire hazard and vulnerability analysis using the WWRA will be available for the next Oregon NHMP update.

Preliminary maps from the WWRA were used in the critical and essential infrastructure analysis. In addition, preliminary hazard and exposure summary statistics from the WWRA for the state of Oregon are as follows:

- 22% of burnable acres in the state have a Moderate-to-High wildfire risk
- 56 million burnable acres across the state (90% of all lands)
- 751,672 people are living at risk to wildfire within Wildland Development Areas
- 27.6 million acres of forest assets are at risk to wildfire

With respect to structures and population density, communities that were evaluated for wildfire risk were either rural (consisting of 1 to 3.9 dwellings per 40 acres and a population density of 28 to 111 people per square mile), suburban (consisting of 4 to 19.9 dwellings per 40 acres and a population density of 112 to 559 people per square mile) or urban (consisting of 20 to 99 dwellings per 40 acres and 560 to 1,371 people per square mile). Highly urbanized areas (100 or more dwellings per square mile and 1,372 or more people per square mile) were excluded.

Factors that contributed to a community being rated as at high risk from wildfire were as follows:

Ignition Risk – A high risk rating was given when fire occurrence exceeded 1 fire per 1,000 acres over 10 years.

Fuel Loading and Hazard – A high risk rating was based on a composite rating based on the following (percents indicate weight each factor is given to the composite rating):

<u>Weather (25%)</u> – The weather risk rating is based on the number of days per season that forest fuels were capable of producing a significant wildfire event as determined by an analysis of daily fire danger rating indices for regulated use areas across Oregon. All of eastern Oregon and interior southwest Oregon are high weather risk.

<u>Slope, Aspect and Elevation (12%)</u> – Slopes greater than 40 percent with south facing aspects at elevations at or below 3,500 feet all contribute to high risk.

<u>Fuels (30%)</u> – Forest fuels that result in fire behaviors of flame lengths exceeding 8 feet; frequent spotting, torching, or crowning such that fire severity is stand replacing. Example fuel conditions include flammable grasses, heavy/flammable brush, and mature timber with slash.

<u>Insect and Disease Damage (20%)</u> – A high risk rating was given for forested areas exhibiting at least 3 dead trees per acre from insect and disease; or at least 3 consecutive years of defoliation from the spruce budworm, as determined by the statewide aerial insect and disease survey.

<u>Fire Regime Condition Class (13%)</u> – Fire regime condition class is a measure of forest conditions that are outside the range of natural variability in fuel conditions as result from increased tree stocking and fuel build-up resulting from fire suppression. Lodgepole pine forests are the exception as they can exhibit a high Fire Regime Condition Class rating even though the conditions are within their range of natural variability. Forests with the high risk Fire Regime Condition Class rating exhibit

excessive surface fuels, brush, live and dead mid-canopy or ladder fuels as well as canopy fuels in standing dead and overstocked mature trees. Wildfire under these forest conditions are likely to develop in severe crown fires.

Suppression Capability – Areas at high risk have no organized fire suppression response capability. Areas at moderate risk have wildland forest suppression response, but structural response within 10 minutes is limited.

Values at Risk – High values at risk were defined by population and dwelling densities (urban and highly urbanized), forests containing municipal watersheds and forests managed for wood production.

In summary, the perfect storm for a community at the highest risk of wildfire would be an urban community within interior southwestern or eastern Oregon surrounded by forests of low elevation on south facing slopes exceeding 40 percent in slope; containing high amounts of surface and ladder fuels arising from insect and disease mortality as well as the exclusion of fire due to fire suppression efforts; with little or no organized wildfire suppression capability. On average, 96% of the fires are suppressed at 10 acres or less. Unfortunately, the remaining 4% of the fires tend to be damaging and very difficult to suppress.

Windstorm

The damaging effects of windstorms may extend for distances of 100 to 300 miles from the center of storm activity. Isolated wind phenomena in the mountainous regions have more localized effects. Near-surface winds and associated pressure effects exert loads on walls, doors, windows, and roofs, sometimes causing considerable damage. When severe windstorms strike a community, downed trees, power lines, and damaged property are major hindrances to response and recovery.

Most Vulnerable Communities

The Oregon Coast has several relatively harsh storms during the winter months. Although major damage from these storms is infrequent, the Oregon Coast Region of the state is the most vulnerable to windstorms. The seven coastal counties in the Oregon Coast Region often face 60 to 100 mile an hour winds sometime during the year. While the coast is experiencing severe winds, the Willamette Valley may also face 40 to 60 mile per hour winds from the same storm. Also, the Columbia River Gorge funnels very strong winds, often from east to west. The Northern Willamette Valley/Portland Metro and Mid-Columbia Regions are most vulnerable to this type of wind event.

Major windstorms that can impact large areas of the state, like the Columbus Day windstorm of 1962, are relatively rare. These storms can cause major damage to many areas of the state with the Oregon coastal counties typically suffering the most damage from this type of hazardous event.

The PUC is the entity with primary oversight over the windstorm hazard. PUC lists Benton, Clatsop, Coos, Columbia, Curry, Douglas, Gilliam, Hood River, Lane, Lincoln, Linn, Marion, Morrow, Multnomah, Polk, Sherman, Tillamook, and Washington as the most vulnerable to damage and loss associated with windstorms. The Oregon Climate Service (OCS) and Oregon Climate Change Research Institute (OCCRI) provides weather and climate support.

The identification of communities most vulnerable to windstorms is based on PUC agency staff and OCCRI/OCS staff review.

Winter Storm

A major winter storm can last for days and can include high winds, freezing rain or sleet, heavy snowfall, and cold temperatures. People can become marooned at home without utilities or other services. Severe cold can cause much harm. It can damage crops and other vegetation and freeze pipes, causing them to burst. Unusually cold temperatures are especially dangerous in areas not accustomed to them because residents are generally unprepared and may not realize the dangers severe cold presents.

Figure WS-8: Trucks wait at a truck stop in Troutdale after ice, wind, and snow caused ODOT to close Interstate 84 through the Columbia River Gorge – January 2004
Photo source: William Hamilton, The Oregonian

Heavy snowfall and blizzards can trap motorists in their vehicles and make walking to find help a deadly mistake. Heavy snow can immobilize a region and paralyze a city, stranding commuters, closing airports, stopping the flow of supplies, and disrupting emergency and medical services. Accumulations of snow can cause roofs to collapse and knock down trees and power lines. Homes and farms may be isolated for days. In rural areas, unprotected livestock can be lost. In urban areas, the cost of snow removal, damage repair, and lost business can have severe economic impacts.

When an ice storm strikes, some landscape trees seem to be able to come through with only minor damage, while others suffer the loss of large limbs or sizable parts of their branching structure. In the worst cases, trees may be completely split in two or may have nothing left standing but a trunk. If a tree has been weakened by disease, there may be little that can be done to prevent major breakage or loss when the stresses of a storm occur. However, there are preventive measures that cities and property owners can take to help their trees be stronger and more resistant to storm damage. For more information, see Appendix X: Reducing Ice Storm Damage to Trees.

Heavy accumulations of ice can bring down trees and topple utility poles and communication towers. Ice can disrupt power and communication for days while utility companies repair extensive damage. Even small accumulations of ice can be dangerous to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces.

Exposure to cold can cause frostbite and life-threatening hypothermia. Frostbite is the freezing of body tissue. It most frequently affects fingers, toes, earlobes, and the tip of the nose. Hypothermia begins to occur when a person's body temperature drops three degrees below normal temperature. On average, a person begins to suffer hypothermia if his or her temperature drops to 96 degrees F (35.6 degrees Celsius). Cold temperatures can cause hypothermia in anyone who is not adequately clothed or sheltered in a place with adequate heat. Hypothermia can kill people, and those who survive hypothermia are likely to suffer lasting ill effects. Infants and elderly people are the most susceptible. Elderly people account for the largest percentage of hypothermia victims, many of whom freeze to death in their own homes. Most of these victims are alone and their heating systems are working

improperly or not at all. People who take certain medications, who have certain medical conditions, or who have been drinking alcohol also are at increased risk for hypothermia.

Driving can be tricky in the snow, but once a storm has passed, there is another danger: flying snow from trucks and cars. When snow is warmed by the vehicle, it will begin to melt. Wind and motion cause sections to break off and hit other vehicles. The snow can also fall on the road, melt, and later turn into ice.

Winter storms are considered deceptive killers because most winter storm deaths are related only indirectly to the storms. Overall, most winter storm deaths result from vehicle or other transportation accidents caused by ice and snow. Exhaustion and heart attacks brought on by overexertion are two other common causes of deaths related to winter storms. Tasks such as shoveling snow, pushing a vehicle, or even walking in heavy snow can cause a heart attack, particularly in people who are older or who are not used to high levels of physical activity. Home fires occur more frequently in the winter because people do not take the proper safety precautions when using alternative heat sources. Fires during winter storms present a great danger because water supplies may freeze and it may be difficult for firefighting equipment to get to the fire. In addition, people can be killed by carbon monoxide emitted by fuels such as charcoal briquettes improperly used to heat homes.[5]

One issue concerns the fact that there is not a statewide effort regarding Winter Storm impacts, either historical or for future planning. There are only limited snow fall sensors distributed mainly through the mountain ranges of the state and there is not an annual tracking system in place for snow fall statewide. A program of statewide snow fall sensors would allow us to better understand the impact of Winter Storms on Oregon and have a better means of predicting potential impacts in the future.

Most Vulnerable Communities

The Oregon Department of Transportation (ODOT) is the agency with primary oversight of the Winter Storm hazard. Based on agency staff review of the available hazard data, ODOT lists the Northern Willamette Valley (Linn, Benton, Marion, Polk and Yamhill Counties); the Portland Metro Region (Columbia, Washington, Multnomah and Clackamas Counties); and the Mid/Southern Willamette Region (Lane, Douglas, Josephine and Jackson Counties) as the most vulnerable to damage and loss associated with winter storms because Oregon's most densely populated cities are located within these regions.

The Portland metropolitan area is the most vulnerable not only because it is the most densely populated but also because of its proximity to the Columbia River Gorge. It is not uncommon to have severe ice and sleet storms occurring as cold artic winds blow down the Gorge over east Multnomah County and Portland. These storms have delayed air traffic and even closed the Portland International Airport in the past, thus negatively affecting Oregon's economy. Winter storms often bring ice and sleet that makes driving extremely dangerous. Ice and sleet storms can cripple the movement of goods and services, thus negatively impacting Oregon's economy.

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[5] From *Talking About Disaster: Guide for Standard Messages*, produced by the National Disaster Education Coalition, Washington, D.C., 2004

National Weather Service Winter Storm reports were used as the basis for determining community vulnerabilities. Unfortunately there is only the NWS storm information available for analysis. There is no statewide Winter Storm program to study the impacts of these storms statewide. There is no program to identify annual average snow falls across the state either historical or for planning purposes. Hydrological precipitation information is available but not winter storm and snow fall information.

Local and State Vulnerability Assessment Comparison

Past iterations of the Oregon NHMP stated local and state vulnerability "rankings" separately. No comparison or analysis of similarities and differences among the methods was conducted. For this update, the state placed local and state vulnerability "rankings" side-by-side to identify if and where similarities and differences occur. Following is a summary of basic similarities and differences in these methods as well as in the vulnerability "rankings".

While local risk assessments are standardized and state risk assessments vary from hazard to hazard, there are similarities among these methods. First, in all of these assessments historical events are identified and are the basis upon which probability of future hazard events occurring is determined. Second, based on best available data, vulnerability to each hazard is identified at the local or state scale respectively.

On the other hand, *how* local and state assessments identify vulnerability varies greatly from local to state, as well as across all hazards at the state level. As described on pg XX, local assessments use the OEM Hazard Analysis Methodology that ranks vulnerability to each hazard based on the estimated the percentage of population and property likely to be affected. The "ranking" of vulnerability is based on local knowledge, and is therefore somewhat subjective. This methodology identifies which hazards are priorities at the local level.

As described in the preceding section of this Plan, for the state assessment, each hazard lead assesses vulnerability based on best available data. For some hazards– such as flood, earthquake and tsunami – a significant amount of data is available and supports detailed damage and loss estimates. Projected damages and losses help the state identify which communities are most vulnerable to each hazard. Hazards for which there is limited data available undergo a less rigorous assessment, and identifying which communities are most vulnerable may be more challenging. Each hazard lead is an expert on that particular hazard. Hazard lead knowledge with some combination of research, literature and agency knowledge form the factual basis for each state hazard risk assessment accompanied by some level of subjectivity.

While local and state risk assessment methods are inherently different, there is added value in comparing findings from both. All methods identify hazard priorities. Local assessments identify the hazards to which each community believes they are most vulnerable. State hazard leads identify which communities are most vulnerable to each hazard compared to other communities. These assessment rankings are intended to guide local and state mitigation goals and actions which inform mitigation priorities for local and state NHMPs.

Table 2-V-3 shows a side-by-side comparison of local and state vulnerability rankings. Symbols in this table are defined as:

Local	**State**
H= High Vulnerability	MV= Most Vulnerable Community (as identified by all hazard leads)
M= Moderate Vulnerability	V= Vulnerable Community (as identified by *some* hazard leads)
L= Low Vulnerability	

This side-by-side comparison indicates similarities and differences between local and state vulnerability rankings. For some counties, local and state assessments agree there is a high level of vulnerability to a

hazard, as indicated by both an “H” (high vulnerability) and a “MV” (Most Vulnerable) rankings by local and state assessments respectively. In other instances, local and state rankings are not in sync. For example, a county that did not score itself for a hazard (indicating it is not at risk to that hazard), or scored itself “L” (as having low vulnerability) to a hazard; and the state ranked that county as one of the “MV” (most vulnerable) counties to that hazard.

Time did not permit for an analysis of this table to be conducted during this Plan update cycle. For the purposes of this update, a side-by-side comparison is the extent to which the state is able to address these inconsistencies. However, the state is in the process of exploring what these findings mean and how Oregon can better align local and state risk assessments to identify its most vulnerable communities.

In April 3014, The Department of Land Conservation and Development (DLCD) presented a version of this table at the Oregon Prepared Conference to emergency managers and others involved with LNHMP updates. This presentation initiated a local-state discussion about risk assessments in Oregon; how to enhance the Plan update process at the local level; and how state hazard experts can better inform local jurisdictions on statewide hazard data.

This table will also be presented to the State Interagency Hazard Mitigation Team (IHMT) for feedback on how to best initiate a two-way information sharing dialogue between local and state entities that perform risk assessment updates for NHMPs. Between the 2015 and the next Oregon NHMP update the state will facilitate these discussions. The state is also identifying ways to incorporate this discussion into statewide conferences and trainings.

Table 2-V-3: Local and State Vulnerability Rankings by County

	Coastal Erosion		Tsunami		Drought		Dust Storm		Earthquake		Volcanic		Landslide		Wildfire		Flood		Wind Storm		Winter Storm	
County	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*
Baker					H	MV	M	V	M	V	L		M	MV	H		M		H	V	H	
Benton					L				H	MV	L		L	MV	M		M		M	MV	M	MV
Clackamas					L				H	MV	H	MV	L	MV	M		M	MV	L	V	M	MV
Clatsop	H	MV	H	MV	M				H	MV	M		H	MV	H		H	V	H	MV	H	
Columbia					M				H	V	H		M	MV	M		M	MV	H	MV	H	MV
Coos	M	V	H	MV	M				H	MV	M		M	MV	M		H	V	H	MV	H	
Crook					H		L		L	V	H		L	MV	M	V	H		M	V	M	
Curry		MV	H	MV					H	MV	H		L	MV	H		H	V	H	MV		
Deschutes					L			V	M	V	H	MV			M	MV	L		L	V	H	
Douglas - Central									M	MV		MV	M	MV	H	MV	H		M	MV	H	MV
Douglas - Coastal	L		H	MV					H	MV			M	MV	M		M		M	V	M	
Gilliam					H	MV			M	V	M		M		M		M		L	MV	H	
Grant					H				M	V	L		M	MV	H		H			V	H	
Harney					M			V		V				MV	M		M	V	L	V	M	
Hood River					H				M	V	L	MV	M	MV	M		M		H	MV	H	
Jackson					M				H	MV	L	MV	L	MV	M	MV	M		H	V	H	MV
Jefferson					H			V	L	V	H	MV	L		H	V	M			V	H	
Josephine									H	MV				MV	M	V	M		H	V	H	MV
Klamath					M	MV		V	M	MV	L	MV		MV	L	V	M			V	M	
Lake					H			V	H	V	H		L		M	V	M		M	V	H	
Lane - Central					M				M	MV	M	MV	L	MV	M		H		M	MV	H	MV
Lane - Coastal		V	H	MV					H	MV			M	MV	L		H		H	V	L	
Lincoln		MV	M	MV	L				M	MV	L			MV	M		L	V	H	MV		
Linn									H	MV	H	MV		MV	M		H	V	M	MV	H	MV
Malheur					H	MV	L	V	M	V	M		M	MV	M		H		M	V	M	
Marion									H	MV	M	MV		MV	M		M	V	H	MV	H	MV
Morrow						MV	M	MV	H	V			M		M		H	V	M	MV	H	
Multnomah									H	MV	H	MV	M	MV	M		H	V	H	MV	H	MV
Polk									H	V	M				M		H		H	MV		MV
Sherman					M	MV			L	V	L		M		M		M		M	MV	M	
Tillamook		MV	H	MV	L		L		H	V	M		H	MV	H		H	MV	H	MV	H	
Umatilla								MV	M	V					M		M	V	H	V	H	
Union					M		M	V	M	V			M	MV	M		M		H	V	H	
Wallowa					H				M	V	L		M		H		H		H	V	H	
Wasco					H			V	M	V	L	MV	M	MV	M		L		H	V	H	
Washington					M				H	MV	H		L	MV	M		H	V	H	MV	H	MV
Wheeler									M	V				MV	H	V	M			V	H	
Yamhill					H				H	MV			M	MV	L		H	V	M	V	H	MV

Source: DLCD and OEM

State-Owned and Leased Facilities and Critical and Essential Facilities Exposure Assessment

Requirement: 44 CFR §201.4(c)(2)(ii): Th[e] risk assessment shall include… (ii) (s)tate owned or operated critical facilities located in the identified hazard areas shall also be addressed.

Requirement: 44 CFR §201.4(c)(2)(iii): Th[e] risk assessment shall include… (iii) (a)n overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State shall estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.

According to the Oregon Department of Administrative Services (DAS), the State of Oregon owns or leases buildings having a total value of over $7.3 billion. Because of this investment it is important the State assess the vulnerability of these structures to Oregon's natural hazards, including landslides, floods, volcanic hazards, tsunamis, earthquakes, wildfires, and coastal erosion. The Oregon Department of Geology and Mineral Industries (DOGAMI) assembled the best-available statewide natural hazard data and assessed which state-owned/leased buildings are exposed to each hazard. Data to support this level of analysis was available for the follow hazards: coastal erosion, earthquake, flood, landslide, tsunami, volcano, and wildfire.

Most building data were carried forward from the 2012 Oregon NHMP assessment of state-owned/leased buildings. For the 2015 assessment, this building data (originally digitized by DOGAMI from DAS-supplied spreadsheets) was updated with DAS deletions and additions current as of 2013. Because of imprecise, incomplete, or ambiguous addresses, 205 lower-value entries in the "additions" spreadsheets were not digitized in this study. This amounts to nearly $28 million worth of property, though only about $17 million is within Oregon state boundaries; at least $11 million of that total is located in Utah, Texas, or Washington and therefore outside the bounds of this analysis.

Notably, the DAS building data does not identify "critical and essential" facilities. So, DOGAMI identified indicative descriptors found within building names and usage descriptions (e.g. armory, haz-mat storage, hospital, communication tower, etc.) and identified those facilities critical/essential . It is also important to note this assessment is based on limited data. The DAS buildings list is of variable quality and completeness. Facilities for which there were missing or incomplete address/location information, uncertain matches to older building data, missing or vague names, or locations outside of the State of Oregon were not used in this update.

The DAS database lists 5,693 state facilities owned or leased by 122 state agencies. DOGAMI used the DAS list to locate facilities using Geographic Information Systems (GIS). Figure FAC-V-1 shows the distribution of these 5,693 state-owned/leased facilities within Oregon Emergency Management (OEM) Natural Hazard Mitigation Regions.

Critical and essential facilities not owned or leased by the state are in each map developed for this analysis. These facilities were carried forward from an earlier DOGAMI project to locate critical and essential facilities such as military facilities, schools, communication towers, police and fire stations,

hospitals, etc. These facilities were located and digitized by DOGAMI. Critical and/or essential facilities were defined using criteria developed by FEMA and the International Building Council. Facilities were located and digitized from a variety of sources including FEMA, the US Department of Transportation, DAS, the Oregon Office of Emergency Management, the Oregon Department of Transportation, and others. However, since no property values are included in this data, and they are not owned or leased by the state, they are not included in property value.

Hazard Data Limitations

This assessment evaluates each hazard individually; there are no comprehensive or multi-hazard assessments. In order to prioritize facilities most vulnerable facilities to natural hazards, DOGAMI categorized most hazards with simple classification schemes (most commonly “High”, “Moderate”, “Low”, or “Other”). For each hazard “Other” is used to describe very low hazard areas, unmapped and/or unstudied areas, or zero hazard zones (this is further defined in each of the hazard descriptions below).

Statewide natural hazard data are generalized in several ways and provide a gross view of their distribution and magnitude across the state. They are often combined or derived from other data sources that themselves can have widely different quality, accuracy, attribution, or currency. Future investigations or actual hazard events may substantially modify our understanding of where and when natural hazards might occur.

Last, it is worth noting that building-specific information can make an enormous difference when evaluating the actual damaging effects of natural hazards. For example, a modern seismically-reinforced building may receive far less or no earthquake damage relative to older un-reinforced buildings next door. This study evaluates which facilities are *exposed* to certain natural hazards and, due to data and time limitations, makes no attempt to account for site-specific characteristics.

Oregon Emergency Management Hazard Mitigation Regions

State Owned/Leased Facilities Critical/Essential Facilities

Property Value Statistics within All Hazard Areas				
Region	# of state owned/leased critical/essential facilities (☆)	# of non-state owned/leased critical/essential facilities (★)	# of state owned/leased non-critical/essential facilities (■)	Total property value of state owned/leased facilities (☆ , ■)
1	33	1082	1084	$336,073,104
2	36	696	2806	$1,002,513,064
3	67	1608	2838	$4,277,693,803
4	20	380	1091	$164,409,632
5	29	485	1623	$744,388,079
6	46	844	805	$371,339,811
7	26	335	288	$139,508,917
8	19	183	236	$302,954,349
Grand Total	276	5413	10771	$7,338,880,759

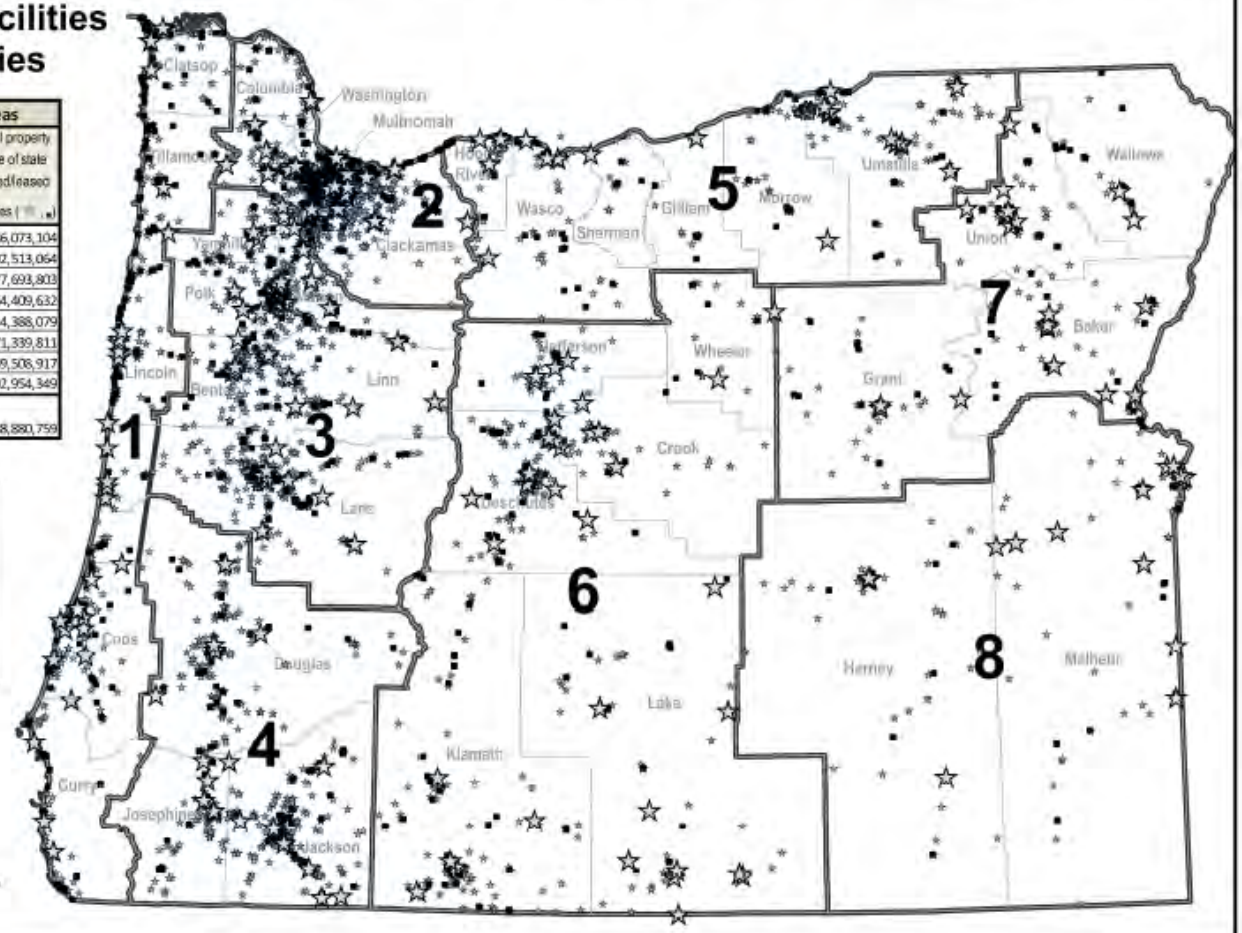

Figure 2-V-FAC-1: Statewide Distribution of State Owned/Leased Facilities and Critical/Essential Facilities

Source: DOGAMI

State Owned/Leased Facilities and Critical/Essential Facilities Within Hazard Areas

The spatial distribution of the facilities in this analysis is not easily viewed on a statewide map. Therefore, maps depicting hazard zones and facilities within those zones have only been created at the regional scale. Those maps can be found later in this Plan, in the Regional Risk Assessment, beginning on page XX.

Coastal Erosion

DOGAMI used the results from several of their coastal erosion studies to develop a coastal erosion hazard zone for this analysis. However, this data does not cover the entire Oregon coastline: coastal erosion hazard zones have not been created for Lane, Douglas, and Coos Counties, and only partial data coverage exists for Curry County. To address these data gaps, DOGAMI excluded those portions of the coast from the analysis, using a 0.5km buffer of the coastline to delineate an "other" value. In areas where mapping exists, the hazard is mapped as Active, High, Moderate, or Low Hazard Zones which, for the purposes of this analysis, were simplified to "High" (encompassing Active and High), "Moderate", and "Other" (encompassing Low hazards and unmapped areas). The Low hazard zones incorporate hypothetical landslide block failures assumed to fail in the event of a M9 Cascadia earthquake and were placed under "Other" due to their very low probability. All other areas of the state received a None attribute.

Coastal Erosion Hazard Facility Summary

Of the 5,693 facilities evaluated, 33 are currently located within a coastal erosion zone representing a value of approximately $7 million. Table 2-V-FAC-3 shows all 33 state owned facilities located within a coastal erosion hazard zone. One of the 33 (ODOT Cape Perpetua Radio building) is identified as a critical or essential facility.

Coastal Erosion Data Limitations

1. Erosion rates used to estimate widths of hazard zones are based on interpretation of a relatively short historical series of aerial photography (1939 to present) and very limited lidar data acquired before 2008. Photos were georeferenced but not necessarily orthorectified and spatial locations may have considerable error.
2. Coastal erosion hazard zones have not been created for Lane, Douglas, and Coos Counties, and only partial data coverage exists for Curry County. Therefore, state owned facilities along the coastline in these areas are not accounted for in this study.

Recommended Data Improvements

As previously stated, the coastal erosion hazard dataset used the best available data from detailed studies conducted by DOGAMI. However, this data does not cover the entire coastline and outside of very small, specific areas, the overall coastal erosion hazard in Lane, Douglas, Coos and Curry counties is undetermined. Therefore, DOGAMI recommends conducting detailed coastal erosion studies on a case-by-case basis within these counties. This recommendation should be included as a specific action item in this Plan.

<Placeholder for Table 2-V-FAC-3: Facilities Located Within a Coastal Erosion Hazard Zone, by Region>

Earthquake

The state facility vulnerability assessment used a combination of datasets that represent key geologic factors that contribute to earthquake hazard damage. This assessment utilizes two statewide earthquake hazard datasets created by DOGAMI to assess the exposure of state owned facilities to these hazards: liquefaction susceptibility and ground shaking intensity (estimated peak ground motions over a 2500 year forecast period). Where they overlapped, ground shaking and liquefaction were combined. The greater hazard of the two at any given location was determined and the higher hazard category assigned.

Ground Shaking

Earthquakes produce various types of seismic waves which can be felt as ground shaking. Ground shaking is stronger close to earthquake sources and weakens with distance. Stronger earthquakes result in more ground shaking, though how it is felt partly depends on the underlying geology at any location. For example, some geologic units can amplify ground shaking while others can lessen it. One simple way to classify ground shaking is to use the Modified Mercalli Index (MMI), which ties how an earthquake is measured to how it is felt as ground shaking.

INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
Shaking	Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
Damage	None	None	None	Very slight	Light	Moderate	Moderate/ heavy	Heavy	Very heavy
Peak Acc	<0.17	0.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
Peak Vel	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116

Peak Acc = Peak ground acceleration (g), Peak Vel = Peak ground velocity (cm/s)

Table 2-V-FAC-7: Modified Mercalli Index

Source: DOGAMI

For the purposes this analysis, DOGAMI created data layers representing the likelihood of maximum ground acceleration and velocity for all earthquake scenarios (crustal and subduction zone) over a 2500 year forecast period. This forecast period was used since it follows the standard used in building codes for the state of Oregon. A Modified Mercalli Index was created from this data and anything receiving a MMI value of VII or greater was divided in to “Low” (VII), “Moderate” (VIII), or “High” (IX and above) earthquake hazard zones. Areas with modeled MMI values less than VII were given an attribute of “Other”. It is important to note that these areas can still sustain damage from earthquakes, particularly if buildings are poorly built.

Liquefaction Susceptibility

Deposits of loose sand or silt that are saturated with water commonly liquefy when shaken strongly or repeatedly by an earthquake. The liquefied materials lose most of their ability to support overlying soil layers and structures: buildings and bridges can sink and tilt, while riverbanks may slump and flow into a river channel. In many large earthquakes, liquefaction results in considerable damage. However, it only occurs in certain types of geologic settings and soil types. As part of the Oregon Resilience Plan, DOGAMI created a data layer depicting liquefaction susceptibility that generally represents where certain geologic formations may liquefy in earthquakes. These liquefiable geologic units are derived from the geologic units within the Oregon Geologic Data Compilation (OGDC v5). The liquefaction data layer from the Oregon Resilience Plan was categorized as Very Low, Low, Moderate, High, and Very High. For the purposes of this analysis, Very Low and Low were combined into " Low"; "Moderate" remained the same; and High and Very High were combined into the "High" category. Areas with no known liquefiable geology were given the attribute "Other". Future geologic mapping, particularly maps that emphasize shallow geology, may change our understanding of where liquefiable deposits occur in Oregon.

Earthquake Hazard Facility Summary

Of 5,693 state facilities evaluated, 5,360 totaling over $7 billion worth of property fall into one of the earthquake hazard zones. Among the 1,141 critical and essential state facilities, 1,069 are in earthquake hazard zones (Table 2-V-FAC-8).

Data Limitations

It is important to note that the methodology used for this vulnerability study is a very broad-scaled approach and does not assess the ability of a building to withstand the earthquake hazard. For a given amount of ground motion, two buildings with different construction types may receive very different types and amounts of damage. The data provided by DAS does not have adequate structure information within its inventory of state owned facilities to conduct a more accurate earthquake vulnerability assessment. All state-owned facilities should have a site-specific study performed in order to more accurately assess hazard vulnerability. Last, future geologic mapping will likely further define liquefiable soils and geologic units as well as faulting style and rates. These could change our understanding of the earthquake hazard in Oregon.

<Placeholder for Table 2-V-FAC-8: Facilities Located Within an Earthquake Hazard Zone, by Region>

Flood

DOGAMI used a combination of Federal Emergency Management Agency (FEMA) effective and preliminary flood zone data, state digitized flood zone data, and FEMA Q3 data to develop a statewide flood hazard zone for this analysis. DOGAMI indicated a flood hazard if a building fell within floodways, 100 year floodplains, or 500 year floodplains. The flood hazard was not divided in to High, Moderate, or Low categories due to the wide variety of flood data, its variable absolute and relative accuracy, and its variable geographic coverage and completeness. In particular, rural or sparsely-populated areas tend to have poorly-mapped or nonexistent flood hazard data. For these reasons, buildings were simply classified as "Hazard Zone" or "Other". "Hazard Zone" indicates a building falls within one of the floodway, 100 year, or 500 year flood hazard zones. "Other" indicates there is insufficient information to determine whether a flood hazard exists for a given site. Buildings with "Other" designations could conceivably face relatively high flood hazards or no flood hazard at all.

Flood Hazard Facility Summary

Of the 5,693 state facilities evaluated, 889 are currently located within a flood hazard zone and have an estimated total value of nearly $900 million. Of these, 143 are identified as a critical or essential facility. See Table 2-V-FAC-2 for a summary of facilities located in the flood hazard zone, by county and OEM Region.

Recommended Data Improvements

The flood hazard dataset used multiple data layers in order to fully cover the state of Oregon. FEMA is currently updating flood data for several counties. The effective FEMA data is the most recently updated data for the state. Both the state digitized flood data and the FEMA Q3 data layers need revision and update because of inaccuracy (created on poor topography source data) and the overall age of the data. These findings demonstrate the need for enhanced flood data in certain areas of the state. Therefore, DOGAMI recommends including flood data enhancement as an action in this Plan.

<Placeholder for Table 2-V-FAC-2: Facilities Located Within a Flood Hazard Zone, by Region>

Landslides and Debris Flow

DOGAMI used their recent landslide inventory publication entitled SLIDO-3 (Statewide Landslide Information Database for Oregon, release 3) and a statewide landslide susceptibility model from the Oregon Resilience Plan to determine which state owned facilities are vulnerable to the landslide hazard. The statewide landslide susceptibility model was originally published with susceptibility values of 1 through 10 using FEMA HAZUS-MH classifications; for this analysis these were reclassified into "Low" (values 1-3), "Moderate" (values 4-6), and "High" (values 7 -10). Atop this, existing landslide outlines from SLIDO-3 were overlain as High hazards to emphasize that pre-existing landslides are relatively more likely to reactivate in rainstorms or during earthquake shaking.

Landslide Hazard Facility Summary

Of the 5,693 facilities evaluated, 5,146 (amounting to nearly $7 billion) are located within High and Moderate landslide hazard areas; this includes 1,038 critical or essential facilities (Table 2-V-FAC-9).

Data Limitations and Recommended Improvements

The statewide landslide susceptibility map generalizes geology and topography at a statewide level using FEMA HAZUS guidelines and indicates large portions of the state are susceptible to landslides. Future geologic mapping may change our understanding of which geologic units are more or less prone to landslides and where they occur. Additionally, site-specific information, if available, would likely supersede the statewide susceptibility data and accurately portray the actual risk to buildings posed by landslides. Additionally, although DOGAMI used the most data available in SLIDO, the database is combination of landslide inventories of varying scale, coverage, and quality. Future studies will likely change the extent and quality of data in SLIDO.

<Placeholder for Table 2-V-FAC-9: Facilities Located Within an Earthquake Hazard Zone, by Region>

Tsunami

DOGAMI used recently-published tsunami inundation model results for the entire coast to determine the tsunami hazard zone for this analysis. The coast-wide inundation models divide tsunami scenarios by whether an earthquake source is local or distant; these in turn are graded in to various inundation zones depending on the size of the earthquake. For the purposes of this exposure analysis, all of these zones are described as the "Tsunami Hazard Zone", with the remainder of the state receiving an "Other" designation to encompass very-low probability events or no tsunami hazard.

Tsunami Hazard Facility Summary

Of the state 5,693 facilities evaluated, 571 are currently located within the tsunami hazard zone and have an estimated total value of $134 million. These facilities are shown on Table 2-V-FAC-5. Of the 690 state buildings, 105 are identified as critical or essential facilities.

Data

Detailed tsunami modeling for the entire Oregon coastline was completed in 2013.

<Placeholder for Table 2-V-FAC-5: Facilities Located Within the Tsunami Hazard Zone, by Region>

Volcanic Hazards

DOGAMI utilized data from the U.S. Geological Survey (USGS) Cascades Volcano Observatory (CVO) to develop the statewide volcanic hazard layer for this analysis. CVO maintains hazard zone data for five volcanic areas in the Cascade Mountains of Oregon: Mt Hood, Crater Lake, Newberry Crater, Mount Jefferson, and the Three Sisters. This assessment scores each facility based on whether it is located within a proximal hazard zone (translating to "High") or distal hazard zone (translating to "Moderate" or "Low"). The maximum credible lahar scenario for each volcano was put in "Low" because it has a very low probability of occurring, while the others were placed in to "Moderate". DOGAMI added its own unpublished lahar data for Mt Hood which resulted in a slight expansion of "Low" hazard areas for the maximum credible lahar scenario. Additionally, DOGAMI included an airfall ash hazard area in the "Low" category to capture USGS depictions of areas with a 1 in 2500 to 1 in 5000 annual chance of receiving 4 inches or more of volcanic ash. Any facility located within these hazard zones is considered vulnerable to volcanic hazards. Outside these hazard zones, the volcanic hazard is undetermined and therefore categorized as "Other."

Volcanic Hazard Facility Summary

Of the 5,693 state facilities evaluated, 537 are located within a volcanic hazard area representing an approximate value of $355 million (Table 2-V-FAC-4). Of those, 55 are located in the "Moderate" or "High" hazard zones. One critical/essential facility falls in a High hazard zone, while the remaining 76 critical/essential facilities fall in to Low volcanic hazard zone.

<Placeholder for Table 2-V-FAC-4: Facilities Located Within a Volcanic Hazard Zone, by Region>

Wildfire

The Oregon Department of Forestry (ODF) participated in a statewide fire hazard and risk assessment in 2012 and 2013 as part of the West Wide Wildfire Risk Assessment for states in the western United States. Following ODF guidance, DOGAMI evaluated building exposure to wildfire using the Fire Risk Index which was classified by ODF in “High”, “Moderate”, and “Low” categories. Urban areas, lake surfaces, and areas bare of vegetation do not have fire risk classifications in the data and are represented here as “other”. For more detailed information regarding this dataset, refer to the West Wide Wildfire Risk Assessment or contact an ODF representative.

Fire Hazard Facility Summary

Of the 5,693 state facilities evaluated, 2,597 are within the overall wildfire hazard zone and total about $1.05 billion in value. Of these, 1372 have a High or Moderate wildfire hazard. Among state critical/essential facilities, 330 have a wildfire hazard in any category (Table 2-V-FAC-6).

Data Limitations

As with several other natural hazards described here, it is important to note that the type of vulnerability study performed for the wildfire hazard is very broad-scaled analysis. All state facilities should have a site-specific study performed because structure risk for fire hazard can be better determined by analyzing the ignition zone surrounding the specific structure and identifying details of the structure type (roof type, construction materials, etc.). Building data provided by DAS does not have adequate structure information within its inventory of state owned facilities to conduct a more accurate fire hazard vulnerability assessment.

<Placeholder for Table 2-V-FAC-6: Facilities Located Within a Wildfire Hazard Zone,

by Region>

Seismic Transportation Lifeline Vulnerabilities

Requirement: 44 CFR §201.4(c)(2)(iii): Th[e] risk assessment shall include… (iii) …The State shall estimate the potential dollar losses to … infrastructure…located in the identified hazard areas.

In 2012 the Oregon Department of Transportation (ODOT) conducted the Oregon Seismic Lifeline Routes (OSLR) identification project. The purpose of the OSLR project was to support emergency response and recovery efforts by providing the best connecting highways practicable between service providers, incident areas and essential supply lines to allow emergency service providers to do their jobs with minimum disruption. It is also intended to support community and regional economic recovery after a disaster event. While the focus of the OSLR project is entirely on state highway right of way, there was an assumption that other transportation modes and facilities are part of an integrated lifelines system. The Oregon Seismic Resilience Plan furthers the discussion of the roles of the different modes and facilities in the aftermath of a CSZ event.

Prior to the OSLR project, most seismic resiliency planning and analysis at ODOT focused on bridges. Recognizing that fully resilient bridges alone would not ensure resilient highways, the ODOT Bridge Section and Transportation Development Division Planning Unit worked together to develop a method for evaluating seismic vulnerability of highways at a corridor level. The methodology included factors related to both the physical characteristics of the highway and a range of trip-ends served that are critical to emergency response and recovery. The result is a backbone system of state highways to connect the areas of the state most vulnerable to a major CSZ event with areas best suited for staging relief efforts and keeping the state economy going, to be prioritized for appropriate retrofit and improvement as funds are made available.

A Cascadia Subduction Zone event has the potential to simultaneously affect all of western Oregon, potentially crippling the statewide transportation network.

The OSLR project study concludes with recommendations for designation of a Seismic Lifelines System. The OSLR project implements Oregon Highway Plan Policy 1E: Lifeline Routes, by recommending a specific list of highways and bridges that comprise the seismic lifeline network. Further, it establishes a three-tiered system of seismic lifelines to help prioritize investment in seismic retrofits on state-owned highways and bridges. The OSLR project was conducted by the ODOT Transportation Development Division (TDD) from September 2011 through April 2012, in coordination and consultation with Bridge, Maintenance, Geotechnical, and other impacted divisions within the agency, as well as with other state agencies including the Oregon Department of Geological and Mineral Industries (DOGAMI) and the Public Utility Commission (PUC) through a Project Management Team (PMT) and Steering Committee (SC). The full report can be found at website:
https://services.oregon.gov/ODOT/TD/TP/Reports/Seismic%20Lifelines%20Evaluation%20Vulnerability%20Synthese%20and%20Identification.pdf

Methodology

The OSLR project management team used the following 5-step process to conduct the OSLR analysis.

Step 1: Identify study corridors

State highways west of US 97 were selected as study corridors that met one or more of the following characteristics (Figure 2-V-LL-1):

- Likely ability to promote safety and survival through connections to major population centers with survival resources
- Current use as a strategic freight and commerce route
- Connection to one or more of the following key destinations of statewide significance:
    - Interstate (I)-84 east of Biggs Junction
    - US 20 east of Bend
    - The California border on I-5
    - The California border on US 97
    - A crossing of the Columbia River into southwest Washington
    - A port on the Columbia or Willamette River
    - A port on the coast
    - Portland International Airport
    - Redmond Municipal Airport

The study corridors were grouped geographically into the following six distinct zones within the western half of the state (Figure 2-V-LL-2):

- Coast (US 101 and connections to US 101 from the I-5 corridor)
- Portland Metro (highways within the Portland metro region)
- Valley (circulation between the Portland metro area and other major population centers in the Willamette Valley)
- South I-5 (the section of I-5 south of Eugene/Springfield)
- Cascades (highways crossing the Cascades mountain range)
- Central (the US 97/US 197 corridor from Washington to California)

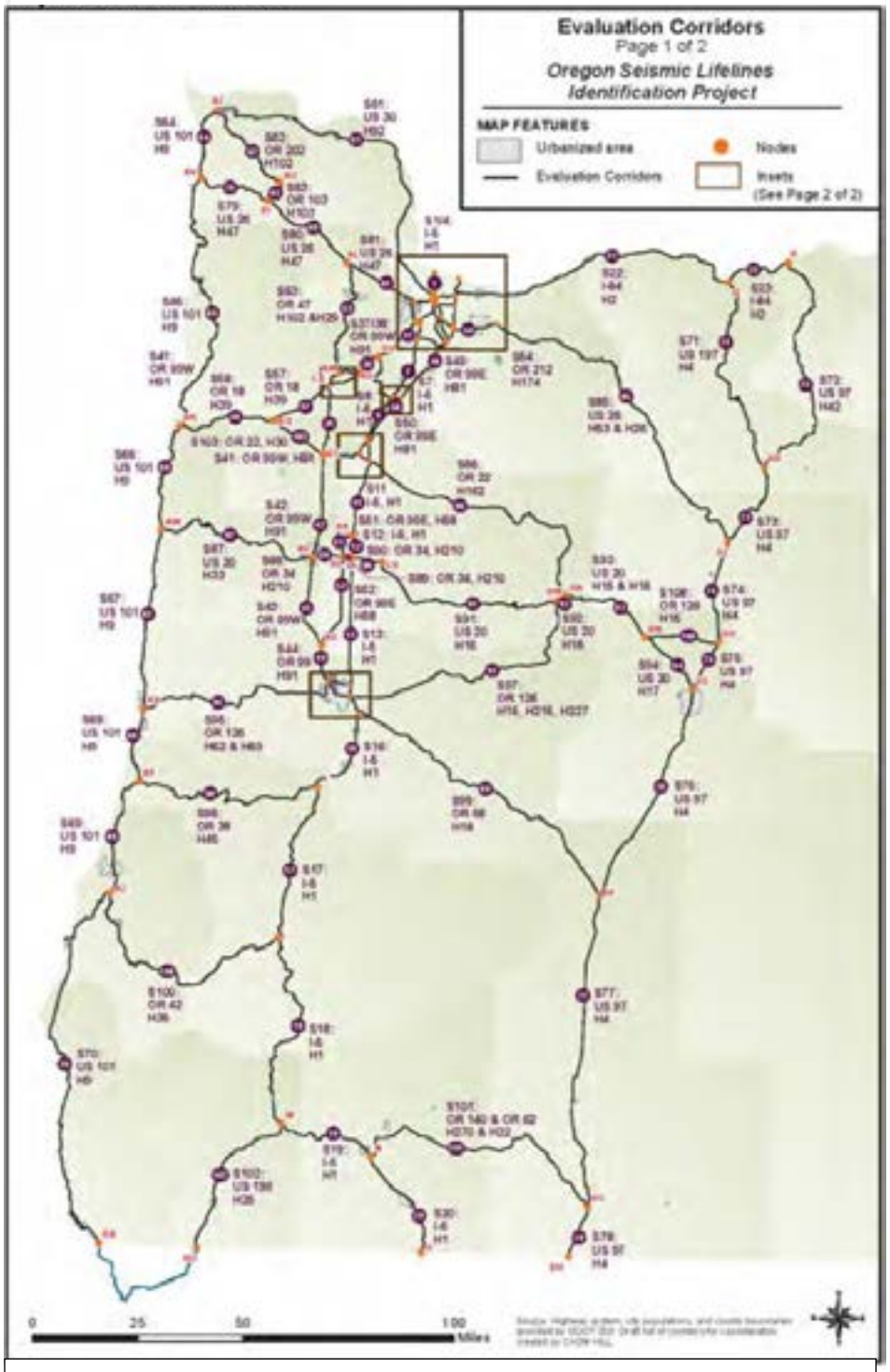

Figure 2-V-LL-1: OSLR Evaluation Corridors.

Source: ODOT

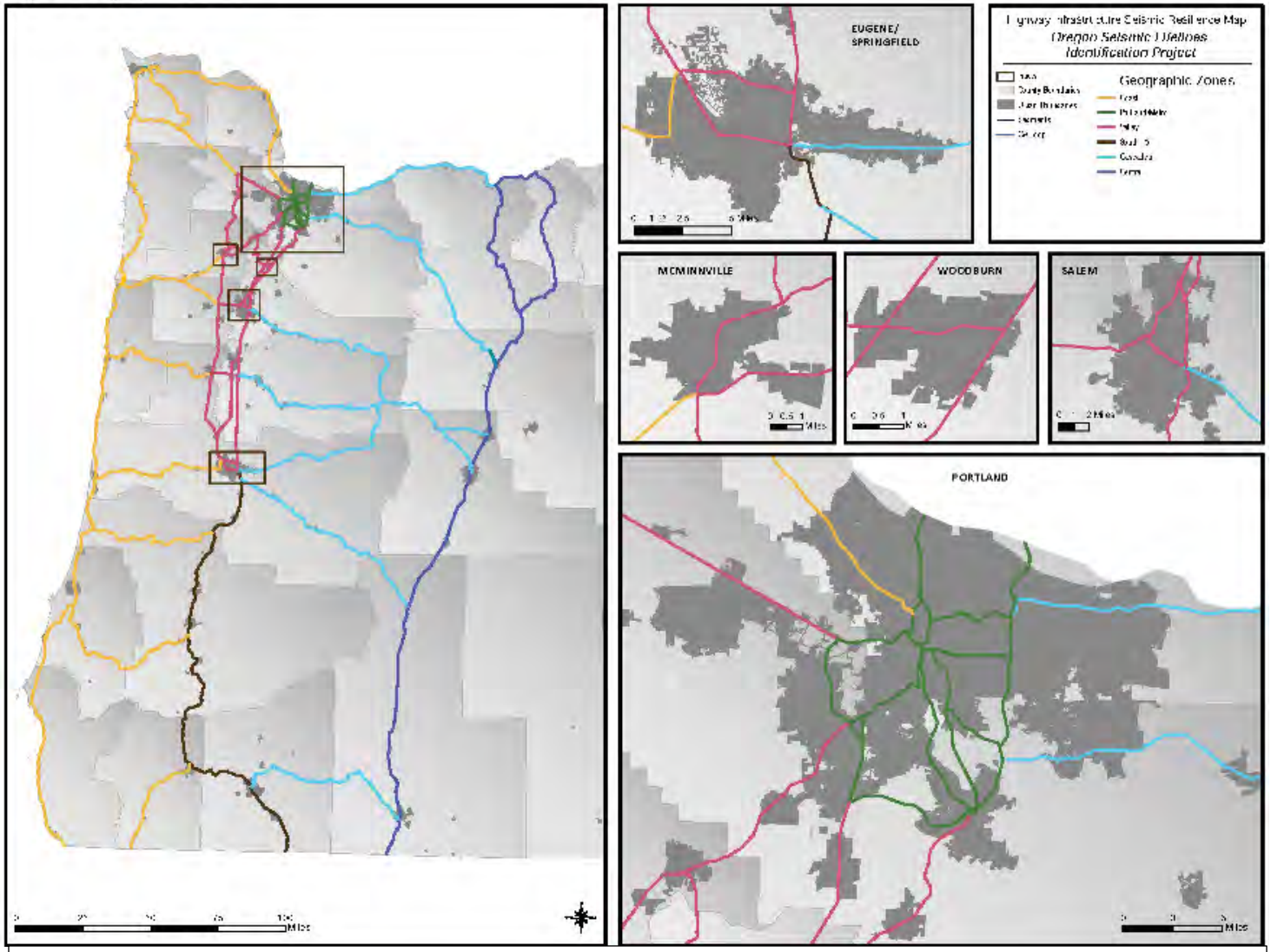

Figure 2-V-LL-2: OSLR Geographic Zones

Source: ODOT

Step 2: Develop Evaluation Framework

The PMT established an evaluation framework that consists of the following four main elements: goals, objectives, criteria, and parameters (Table 2-V-LL-1).

Table 2-V-LL-1: OSLR Evaluation Framework

Goals	Objectives	Criteria
1. Support survivability and emergency response efforts immediately following the event *(immediate and short-term needs)*	1A: Retain routes necessary to bring emergency responders to emergency locations	• Bridge seismic resilience • Roadway seismic resilience • Dam safety • Roadway width • Route provides critical non-redundant access to a major area • Access to fire stations • Access to hospitals • Access to ports and airports • Access to population centers • Access to ODOT maintenance facilities • Ability to control use of the highway
	1B: Retain routes necessary to (a) transport injured people from the damaged area to hospitals and other critical care facilities and (b) transport emergency response personnel (police, firefighters, and medical responders), equipment, and materials to damaged areas	• Route provides critical non-redundant access to a major area • Bridge seismic resilience • Dam safety • Roadway seismic resilience • Access to hospitals • Access to emergency response staging areas
2. Provide transportation facilities critical to life support for an interim period following the event *(midterm needs)*	2A: Retain the routes critical to bring life support resources (food, water, sanitation, communications, energy, and personnel) to the emergency location	• Access to ports and airports • Bridge seismic resilience after short term repair • Dam safety • Roadway seismic resilience • Access to critical utility components (such as fuel depots and critical communication facilities) • Access to ODOT maintenance facilities • Freight access
	2B: Retain regional routes to hospitals	• Access to hospitals
	2C: Retain evacuation routes out of the affected region	• Access to central Oregon • Access to ports and airports • Importance of route to freight movement

Evaluation Framework

Goals	Objectives	Criteria
3. Support statewide economic recovery *(long-term needs)*	3A: Retain designated critical freight corridors	• Freight access • Bridge seismic resilience after short-term repair • Roadway seismic resilience after short-term repair • Route provides critical non-redundant access to a major area • Access to ports and airports • Access to railroads
	3B: Support statewide mobility for connections outside of the affected region	• Access to central Oregon • Access to ports and airports • Access to railroads
	3C: Retain transportation facilities that allow travel between large metro areas	• Route provides critical non-redundant access to a major area • Connection to centers of commerce

Source: ODOT

The criteria in the evaluation framework fell into three categories—connections, capacity, and resilience. Criteria within each category are listed in Table 2-V-LL-2. All criteria are formulated so that a favorable performance is rated “high” and an unfavorable performance is rated “low;” “moderate” indicates a middle rating.

The “Connections” category of criteria includes all criteria relating to proximity to key resources and geographic areas likely to be essential after a seismic event.

The criteria listed under the “Capacity” category measure the characteristics of the roadway itself. These criteria may be important in the case of a seismic event because they can help determine how usable the actual roadway will be for large volumes of traffic, quick evacuation, or moving freight to and from populated areas.

The “Resilience” criteria assess the likely capability that a corridor will function in the aftermath of a major seismic event, with or without a short term repair.

Table 2-V-LL-2: OLSR Evaluation Criteria by Group

Connections	Capacity	Resilience
• Access to fire stations • Access to hospitals • Access to ports and airports • Access to railroads • Access to ODOT maintenance facilities • Access to population centers • Access to emergency response staging areas • Access to critical utilities • Access to central Oregon	• Width of roadway • Ability to control use of the highway • Freight access	• Bridge seismic resilience • Roadway seismic resilience • Bridge seismic resilience after short-term repair • Roadway seismic resilience after short-term repair

Source: ODOT

Step 3: Analyze Selected Highways

Each of the criteria were weighted and ranked for each study segment.

Step 4: Solicit Feedback from Steering Committee

The OSLR project team used the results of the evaluation to identify a three-tiered seismic lifeline system—Tier 1 being the highest priority roadway segment, Tier 2 being the next highest, and Tier 3 being the third highest priority grouping to functions as follows:

- **Tier 1**: A system that provides access to and through the study area from Central Oregon, Washington, and California, and provides access to each region within the study area
- **Tier 2:** Additional roadway segments that extend the reach of the Tier 1 system throughout seismically vulnerable areas of the state and that provide lifeline route redundancy in the Portland Metro Area and Willamette Valley
- **Tier 3:** Roadway segments that, together with Tier 1 and Tier 2, provide an interconnected network (with redundant paths) to serve all of the study area

Step 5: Propose a System of Lifeline Routes

The proposed Tier 1 lifeline network shown provides roadway access to within about 50 air miles of all locations in western Oregon. Total roadway miles for each tier are as follows:

- Tier 1: 1,146 miles
- Tier 2: 705 miles
- Tier 3: 422 miles

This provides a total of 2,273 miles of designated lifeline route. Study routes not identified as seismic lifelines total 298 miles. Figure 2-V-LL-3 shows the proposed seismic lifeline routes with tier designations.

Table 2-V-LL-3 contains a tabulation of lifeline roadway miles within three classifications (high, moderate, low) of peak ground acceleration (PGA) coefficients, by tier for the CSZ seismic event. These CSZ PGA zones generally correlate to geographic areas with the high acceleration zone being the coast and Coast Range Mountains, the moderate acceleration zone the inland valleys, and low acceleration zone the Cascades and Central Oregon.

Table 2-V-LL-3: Lifeline Roadway Length by CSZ Seismic Acceleration Zone and Tier, in Miles

CSZ PGA Zone	Approximate PGA (g)	Tier 1	Tier 2	Tier 3	Total
High	0.56 – 0.96	217	211	236	664
Moderate	0.24 – 0.48	540	313	127	979
Low	0.08 – 0.16	389	181	59	630
Total		1,146	705	422	2,273

Source: ODOT

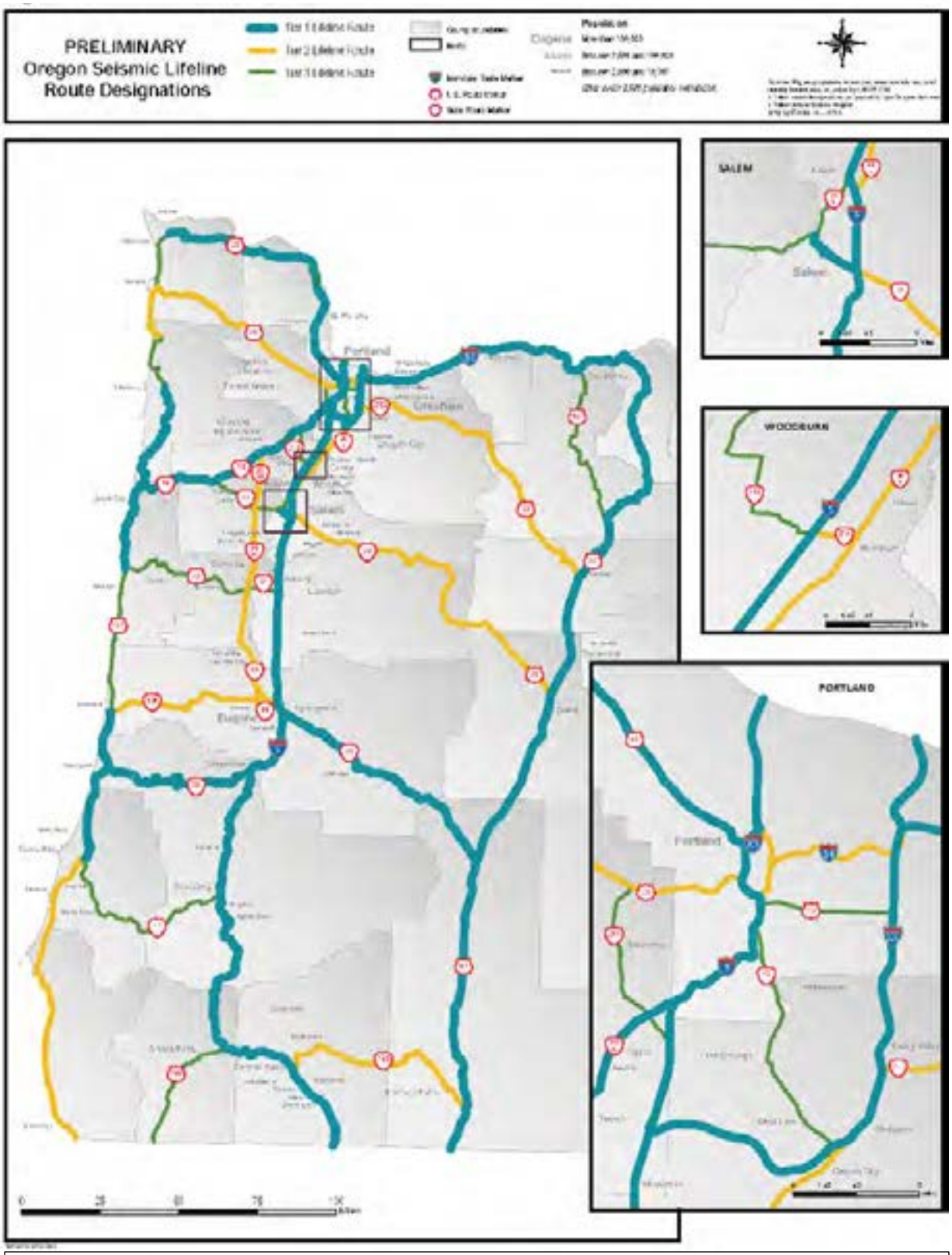

Figure 2-V-LL-3: Preliminary Oregon Seismic Lifeline Routes, by Tier

Source: ODOT

Seismic Hazards Affecting Lifeline Routes

The following seismic hazards have the potential to affect the seismic vulnerability of structures (such as bridges, retaining walls, culverts, and tunnels) and roadway grades along the lifeline routes:

Ground Shaking. Ground shaking is a function of the distance to the earthquake epicenter, the magnitude of the earthquake, regional bedrock properties, and the stiffness of the site-specific soils. It includes the potential for ground amplification because of soft soil deposits. The effects of ground shaking, including the intensity, frequency content, and duration of the shaking, can physically damage structures (such as bridges, culverts, retaining walls, and tunnels), as well as trigger other seismic hazards (such as liquefaction and landslides).

Coseismic Deformation. During a subduction zone earthquake, the tectonic plates undergo elastic deformation on a regional scale, resulting in the potential for several meters of permanent uplift or subsidence that could occur along the entire rupture zone, as expected along the entire Oregon Coast for the CSZ magnitude 9.0 event. Coseismic subsidence can affect tsunami wave heights and run-up. I f the ground subsides during the seismic event, the effective tsunami wave and associated run-up are increased by the amount of subsidence. In addition, coseismic deformation can reduce ground elevations along low-elevation roadway grades to the extent that the elevations end up below design sea level following coseismic subsidence.

Liquefaction. Soil liquefaction is a phenomenon by which loose, saturated, and sandy/silty soils undergo almost a complete loss of strength and stiffness because of seismic shaking. Its occurrence along highway corridors is likely most significant at bridge sites (which are often near bodies of water) or along roadways that are adjacent to bodies of water (such as estuaries, rivers, and lakes). Liquefaction may cause failure of retaining walls from excessive earth pressure, movement of abutments and slopes caused by lateral spreading (liquefaction-induced slope instability), and loss of bearing or pile capacity for bridge abutments and pile caps.

Cyclic Degradation of Clays. The cyclic degradation of clays is a process by which clayey soils may lose the majority of their strength and stiffness because of cyclic shaking. Cyclic degradation of clays is typically associated with sensitive and soft clays. As with liquefaction, these susceptible soils are typically located at or adjacent to bodies of water.

Landslides. Landslide hazards are most likely to occur at locations of steeply sloping ground within the Coast Range and Cascade Mountains, or near alluvial channels. Landslides located above a roadway may lead to the blockage of a road from debris buildup. Landslides located below a roadway may cause undermining and loss of road grade. Landslides can occur at locations with recognized slope instabilities, but they can also occur in areas without a historic record of landslide activity.

Fault Rupture. During shallow crustal earthquakes, the rupture of a fault may propagate to the ground surface and lead to horizontal and/or vertical displacements of the ground. These displacements may be on the order of several meters and will depend on the size of the earthquake and the proximity of the fault plane to the ground surface. The effect of fault rupture is much more devastating for structures, such as bridges, than it is for roadways.

However, the thoroughness of current mapping of faults for the State of Oregon is uncertain and very few of the observed earthquakes in Oregon are associated with mapped crustal faults. It is anticipated that, given the heavy vegetative cover for a lot of Oregon and the short period of time for which records have been kept, not all active faults have been identified.

Tsunamis. Tsunamis may affect lifeline routes near and adjacent to the coastline. The resulting water forces can damage structures within the tsunami run-up zone, and can also cause debris buildup or inundation and the washing away of roadway grades.

Seiche Waves. Seiche waves are resonance waves that are caused by seismic shaking of enclosed bodies of water, and often occur at distances far from the earthquake epicenter.

The hazards listed previously all have relevance to seismic lifeline routes. However, fault rupture, cyclic degradation of clayey soils, and seiche wave hazards were not further evaluated because a CSZ event is not a fault rupture event, there is limited information on clay deformation and the affected areas are likely to also be subject to liquefaction which is considered and seiche waves are limited in height so not expected to have destructive effects on the studied highways. (See Figures 4-1, 4-4 and 4-5)

State Vulnerability

Given the current conditions of the state highway system, the western half of Oregon will be profoundly impacted by a Cascadia Subduction Zone that will fragment major highways by damaging and destroying bridges, triggering landslides that obstruct and/or undermine roadways, other geological hazards such as soil liquefaction and the potential for tsunami that could overwhelm low-lying transportation facilities.

Significant loss of life is likely in tsunami prone areas. Additional loss of life from untreated injuries and disease due to a fragmented response network could also be significant. Loss of life due to structural collapse could be widespread, exacerbating by the duration of ground shaking and the size of the event at the coast, in the Coast Range, along the Lower Columbia, in the Metro area and in the central valleys.

The long term economic impacts would be profound. Many buildings would collapse of suffer significant damage, residential, commercial and industrial. Supply lines for reconstruction materials would be disrupted and the transportation system capacity to move goods is likely to be usurped for a period of weeks for response/survival supplies and materials and personnel needed to re-establish essential services. The ability of employees and customers to get to businesses could be disrupted for weeks if not longer. Smaller and locally based businesses cannot typically survive long periods of closure.

A program to immediately (within the next few years) retrofit all seismic lifeline routes in western Oregon to current design standards is not possible with current budget limitations. Even if the State were able to embark on a program of rapid seismic strengthening of the entire highway system, let alone other regional and private transportation assets, it would be prudent to begin where the most benefit is accomplished in the least time for the least cost. That is a key premise of the development of the OSLR project and the Seismic Options Report that was, in part, based upon it.

Statewide Loss Estimates

The OSLR project includes consideration of the costs of retrofitting bridges and other highway facilities to support the tiering decisions and a preliminary work for revenue requests for implementation. Cost estimates were made for construction projects to mitigate or correct vulnerabilities on the recommended Seismic Lifelines system. Details can be found in Appendix E of the Seismic Options Report developed by ODOT staff to brief executive staff and OTC.

Appendix F of that report considers the **Estimated Economic Impact Due to Failure of Transportation Infrastructure.** This analysis was done to answer a slightly different question: what is the value of making the recommended improvements to the identified lifeline routes?

> *"This analysis evaluated four alternative scenarios in order to gain a sense of the potential loss in production activity we could expect due to the damage to the transportation system after a major seismic event. Four scenarios representing seismic preparation and repair demonstrate the value added (impacts avoided) to the Oregon economy. Significant economic losses in production activity can be avoided by preparing for a major earthquake ahead of time. With no preparation ahead of time, Oregon could lose up to $355 billion in gross state product in the 8 to 10 year period after the event. Proactive investment in bridge strengthening and landslide mitigation reduces this loss between 10% and 24% over the course of the eight years simulated for this analysis."*

It is important to note that the losses considered in the economic analysis only considered impacts directly related to transportation system failures. It did not account for impacts outside of the transportation economic impacts such as the collapse of industrial or commercial buildings or basic service failures. Even so, the benefit to cost ratio of making needed improvements to the Seismic Lifelines system is 46:1.

Figure 2-V-LL-4 shows seismic vulnerability of proposed lifeline routes relative to projected ground shaking form a CSZ event. Figure 2-V-LL-5 shows bridges in tsunami zones. These are the most significant vulnerabilities of the state highway system.

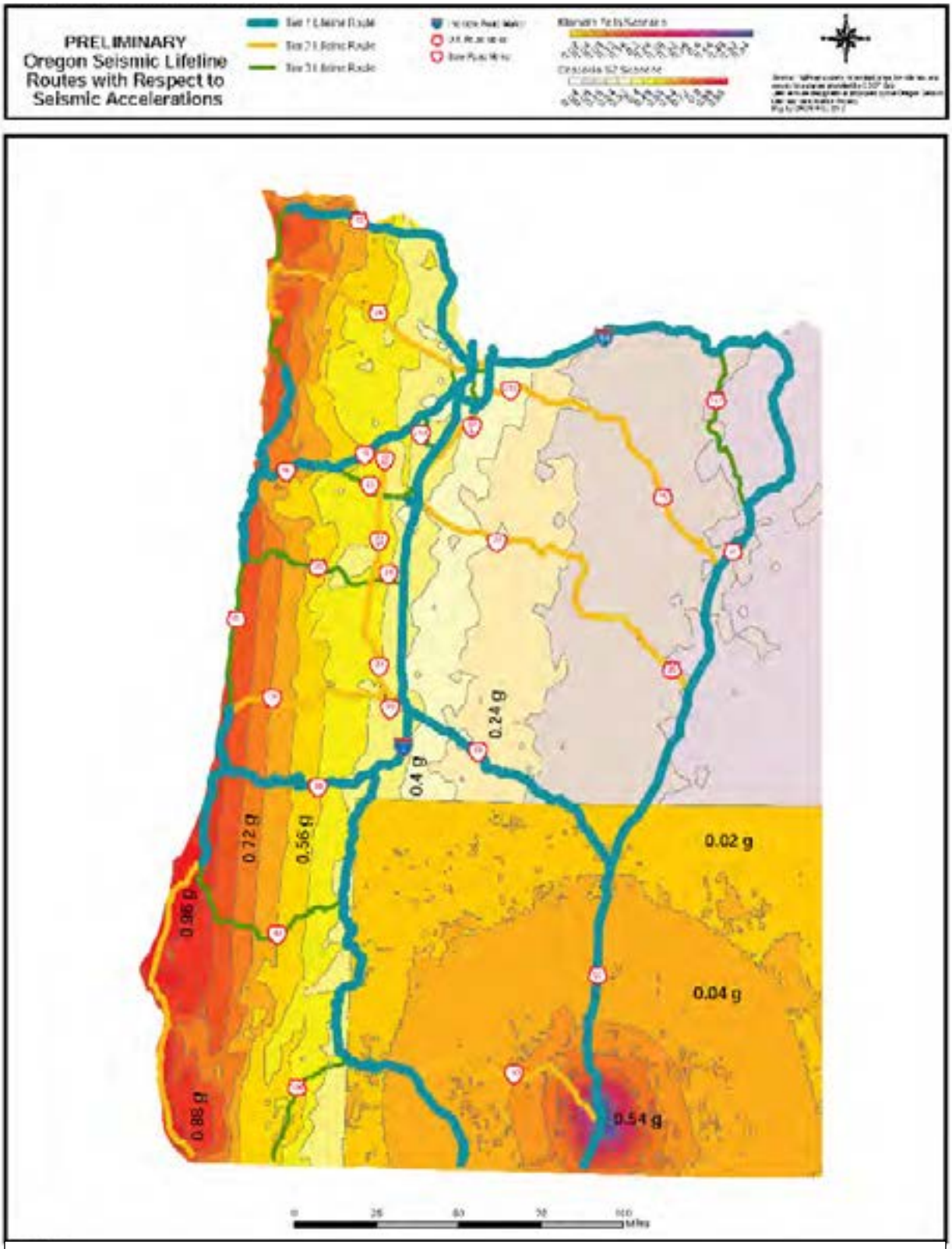

Figure 2-V-LL-4: Preliminary Seismic Lifeline Routes and Seismic Acceleration

Source: ODOT

Most Vulnerable Jurisdictions

The OSLR analysis did not focus at a jurisdictional level. The "planning area" was essentially state right-of-way connecting to population centers and critical resources. The locale referents were large geographic areas with similar risk situations.

The design events considered in the OSLR project are:

- CSZ moment magnitude (Mw) 9.0 earthquake scenario, which has the potential to affect all of western Oregon (as well as northern California, western Washington, and southwestern British Columbia)
- A design-level Klamath Falls crustal earthquake scenario, Mw 6.5, which is limited to the Klamath Falls region because Klamath Falls area is the only region of the state with known significant seismic hazard that is not at a significant level of risk from the CSZ event.

The most vulnerable jurisdictions for a CSZ event are all of the coastal ports, cities, towns and counties. The impacts to the east are less predictable, but expensive losses are also expected in river-dependent areas in the Portland area and at Columbia River ports. The extent of the damage in most of the state will vary with the current conditions including the time of day (extent that highways and public and business buildings are occupied), soil saturation conditions and the size of the earthquake.

<u>Coastal Counties</u>: Most vulnerable to ground shaking, tsunami, landslide and rockfall causing likely long-term impacts on all structures and utilities: Curry, Coos, coastal Douglas, Lane, Lincoln, Tillamook and Clatsop Counties

<u>Lower Columbia River Area</u>: Vulnerable to ground shaking, port and navigation hazards, liquefaction: Columbia, Multnomah, Hood River Counties and river ports

<u>Portland Metro Area</u>: Ground shaking, extensive liquefaction damages to industry, fuel storage, and major bridges in addition to widespread ground shaking damage

<u>Coast Range, I-5 Corridor Valleys</u>: Fragmented surface transportation infrastructure depending upon the extent of ground shaking, likely disruptions of most utilities

<u>Cascade Mountains and Central Oregon</u>: Redmond Airport is the FEMA staging area for federal emergency operations in a major catastrophic event. Connecting the central valleys to US 97 east of the Cascades is important strategically for response efforts and long-term economic recovery. Though the damage to highways is anticipated to be relatively minor, making vulnerable facilities resilient is a high priority to ensure statewide resilience.

Bridges: Bridges are the most significant vulnerabilities of the state highway system. They are primarily vulnerable to the following seismic hazards:

- Ground shaking, which can results in structural damage of the bridge elements
- Liquefaction, which can result in movement or failure of the abutments and/or the bridge piers
- Tsunamis that can scour or result in large loads on bridge piers and abutments and, if high enough, can damage the bridge superstructure
- Landslides that can undermine a bridge

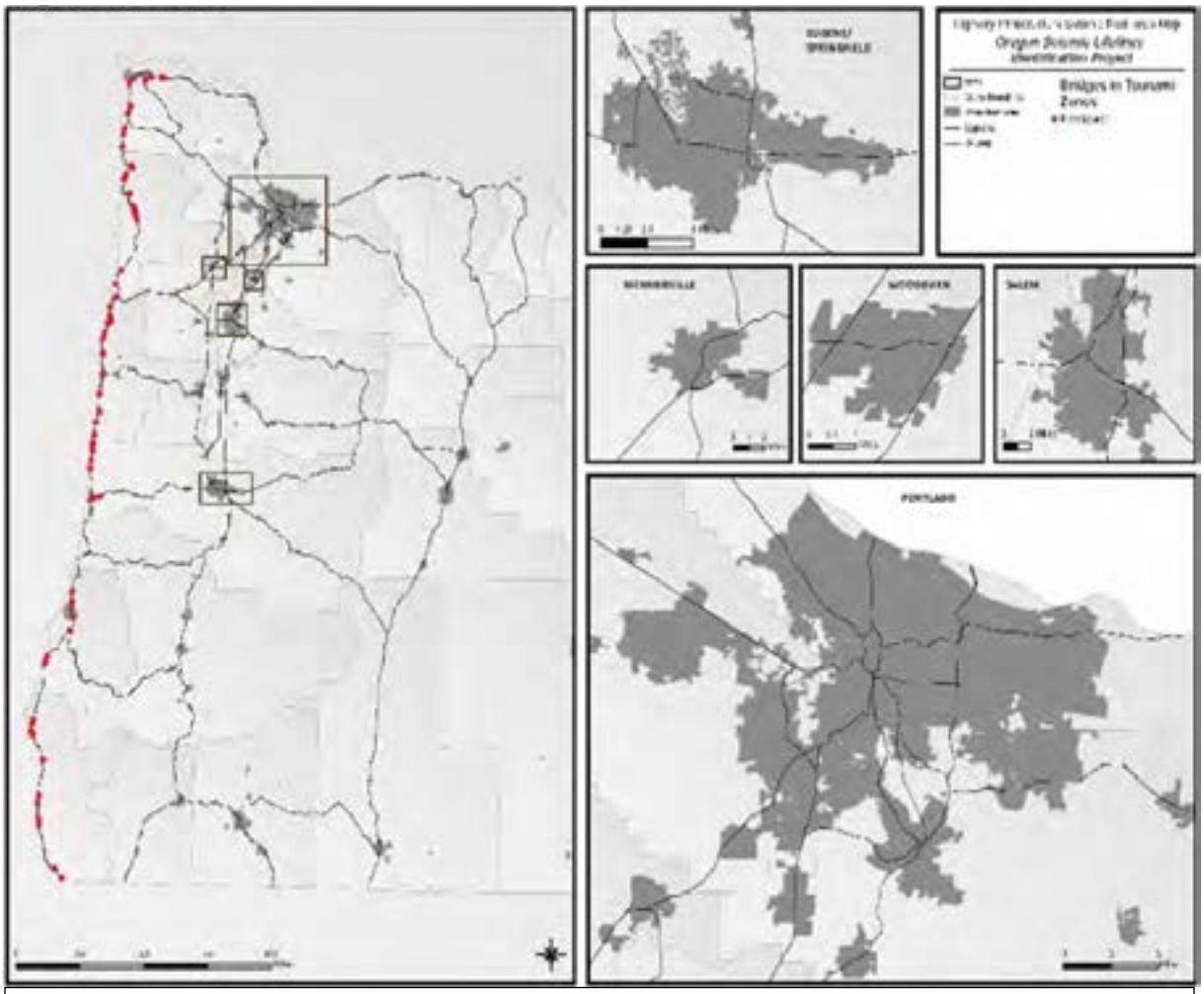

Figure 2-V-LL-5: Bridges in Tsunami Zones

Source: ODOT

Road Grade Vulnerabilities: Roadway grades are vulnerable to the following seismic hazards:

- Ground shaking, which can result in structural damage of roadway elements, including culverts, retaining walls, and abutments
- Liquefaction, which can result in movement or failure of the slopes and ground under and adjacent to the roadway
- Landslides, which can results in failure of the slope above the roadway (which may lead to the blockage of a road from debris buildup) and/or failure of the slope below the roadway (which may result in loss or complete failure of road grade). Landslides may be known, new or ancient slides reactivated by ground shaking. Landslide potential is most prominent in the Coast Range and Cascade Mountains.
- Tsunamis, which can scour or deposit debris on the roadways making them inaccessible
- Coseismic deformation, which can result in the roadway grade being below design sea level

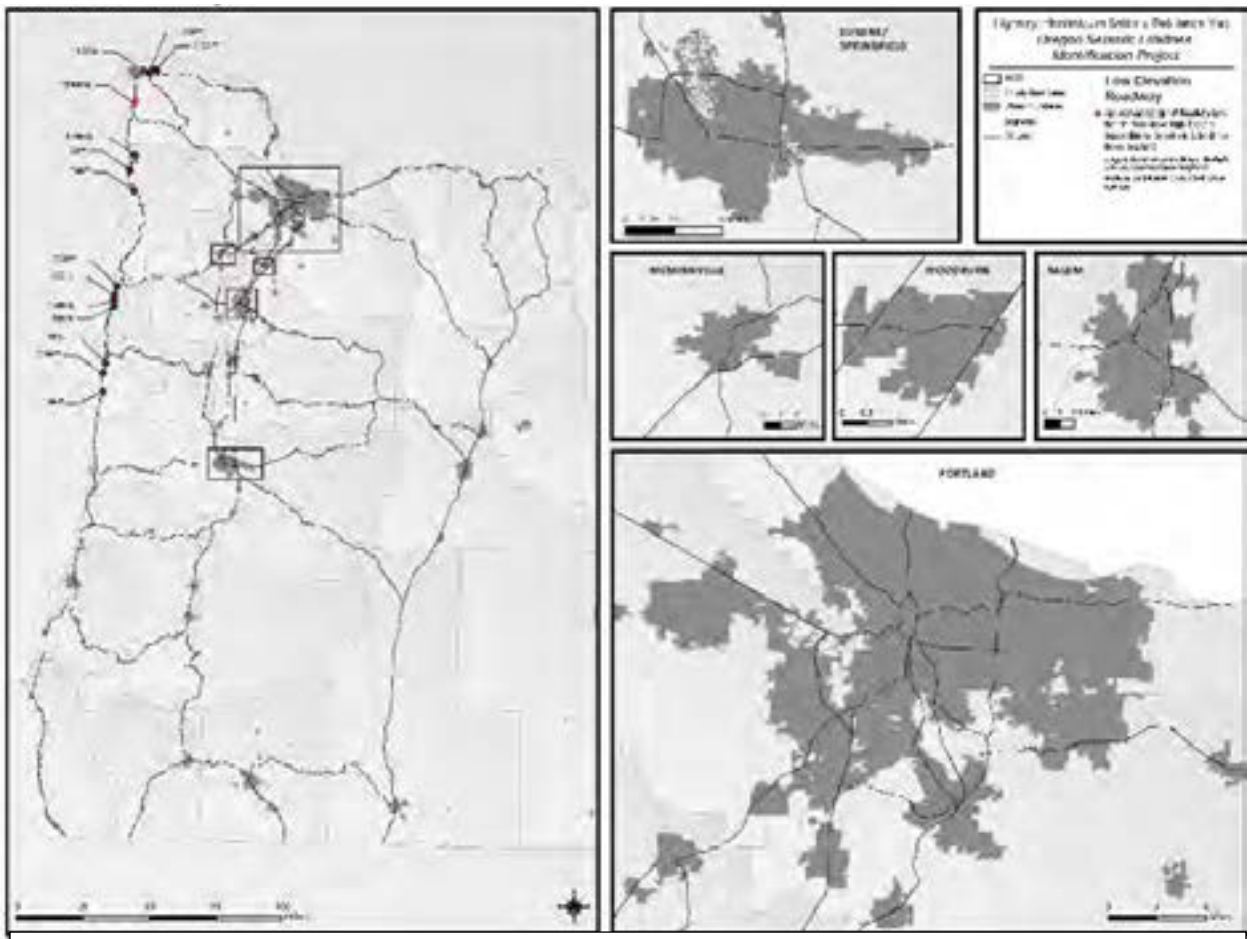

Figure 2-V-LL-6: Low Elevation Roadways

Source: ODOT

Tunnels: Tunnels generally perform well in seismic events; however, some amount of rock fall and structural damage is likely, particularly at portals. The length of tunnels along each segment was tabulated.

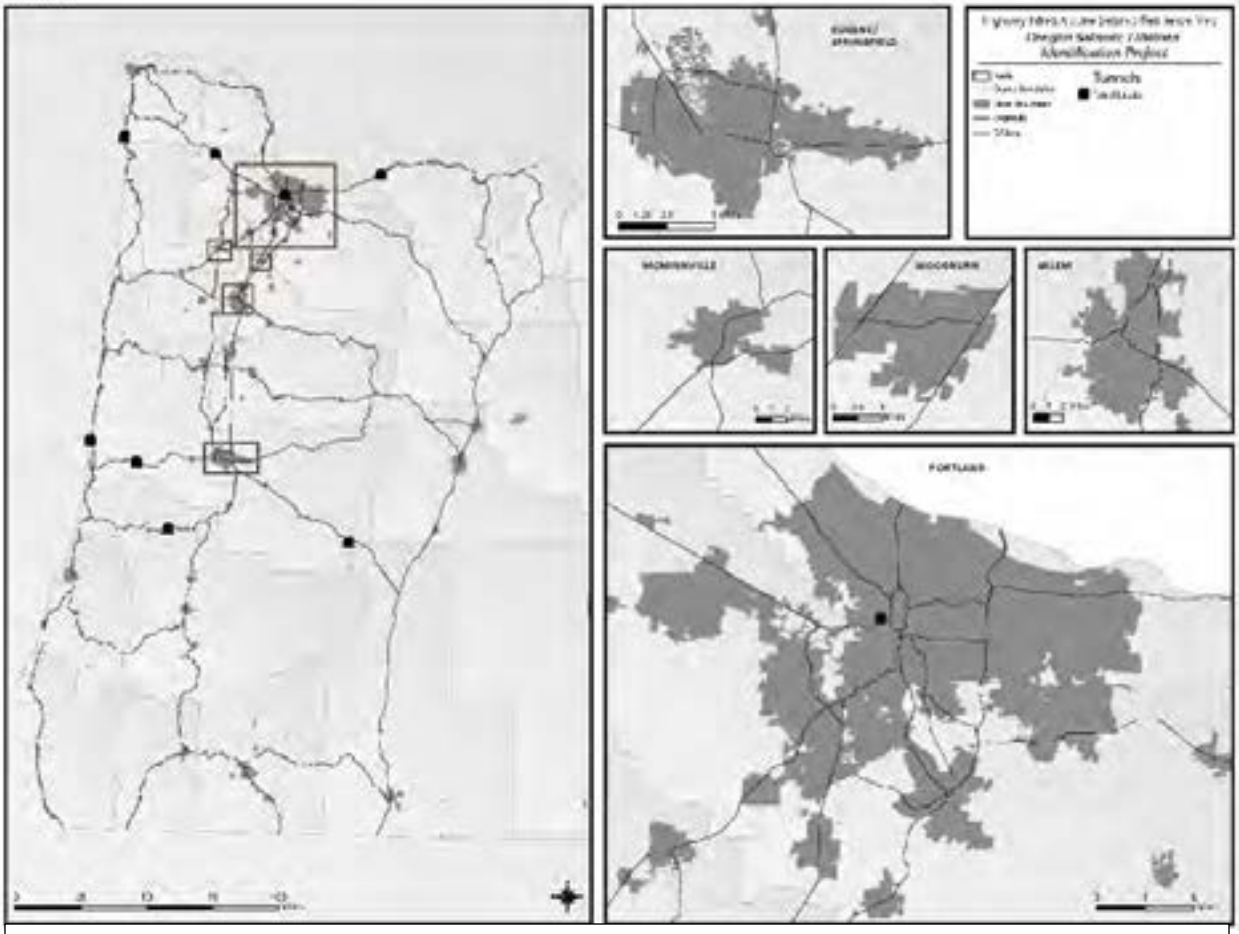

Figure 2-V-LL-7: Tunnels

Source: ODOT

Dams: Dams can pose significant risk to roadways because of releases of large volumes of water that can wash out roadway grades and scour out bridge foundations. This sudden release of water could be due to a dam failure, intentional rapid drawdown in response to structural damage, or overtopping due to a landslide into the upstream pool. Furthermore, rapid drawdown of water levels can also cause slope failures upstream of the dam along the edge of the reservoir. The dams identified in this study are those that have a potential to pose a risk to a state highway. Only one segment was noted to be at risk per dam, in spite of the fact that a dam failure may cause damage on multiple downstream segments. In general, segments farther downstream are at lower risk due to attenuation of the flood wave and the fact that further downstream waterways and crossings generally have a larger capacity.

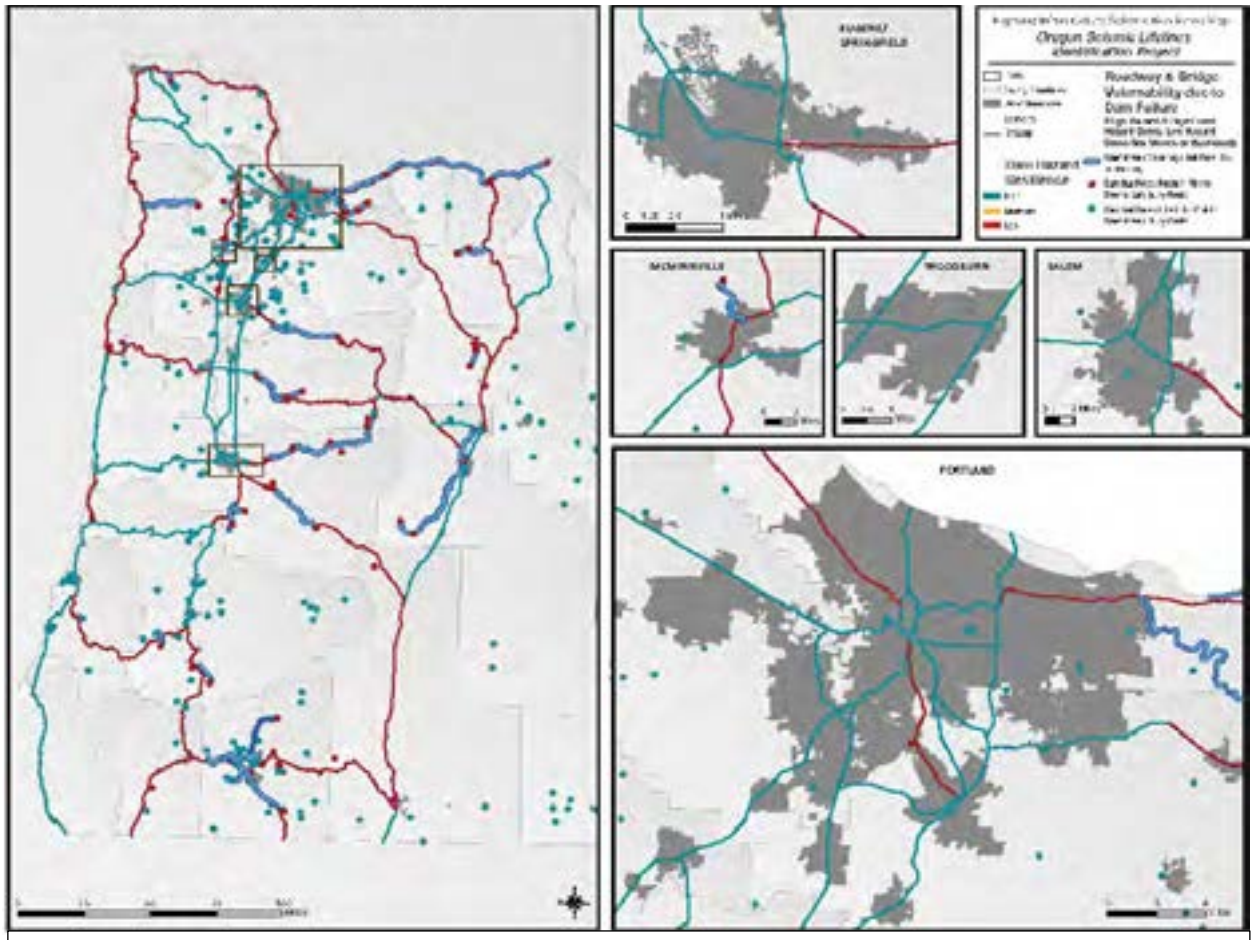

Figure 2-V-LL-8: Roadway and Bridge Vulnerability to Dam Failure

Source: ODOT

Data

The main sources of data used to analyze the seismic vulnerability of each highway segment include:

- ODOT GIS Database.
- DOGAMI References.
- U.S. Geological Survey (USGS) Seismic Hazard References.
- Risks from Earthquake Damage to Roadway Systems (REDARS2) Data.
- DOGAMI and the Federal Emergency Management Agency evaluations of the potential impacts of a major seismic event in Oregon,
- Local knowledge of CH2M HILL staff who have lived and worked in these regions
- Interviews with key maintenance and technical staff at ODOT
- Interviews of technical and field staff at DOGAMI
- Public mapping databases, including aerial photographs, digital terrain models (DTMs), and transportation GIS databases

Data Limitations

The goal of the seismic vulnerability assessment was to use the best available data to make informed and rational seismic lifelines route decisions at the current time. A complete and thorough engineering evaluation would require a much larger project and longer timeframe than is currently prudent. However, the available data is believed to have been judiciously used to enable the development of reasonable criteria and procedures for selecting a backbone system of seismic lifeline routes that will meet ODOT's needs.

During the last 15 years ODOT Bridge Section has compiled statewide hazard and vulnerability data including data on bridge seismic vulnerabilities and existing landslides, while other state and federal agencies have compiled geographic and other data defining seismic risks including predicted tsunami inundation zones. That work is the foundation of this study. Most of the earlier studies have been either comprehensive (statewide) but imprecise, or precise but not comprehensive.

Some statewide information used in the OSLR analysis (for example, the landslide data) was compiled from various sources and is based on varied data-gathering technologies and data-evaluation methods. Therefore, the data are highly variable and are not precise or consistent as a whole. Some older statewide or region-wide data were used in this project in place of more recent site-specific information to provide a platform to make relative comparisons (rather than absolute measures) of seismic risks along various candidate lifeline routes.

Recommended Next Steps

This report provides ODOT with guidance about which roadways are most important for response and recovery following a major earthquake and which roadways are most easily prepared for, and repaired after, a major seismic event. Tier 1 lifeline routes are the most critical highways identified to provide statewide coverage; Tiers 2 and 3 lifeline routes would increase the usability of the system and add access to other areas. The Tier 1 routes have been divided into two phases for planning purposes. Phase one engineering and site evaluations are under way.

The next steps in the process of planning for a seismic event are to do engineering and site evaluations of the recommended routes to inform prioritizing specific mitigation and retrofit projects on these lifelines. Although this study has provided comparative results for seismic vulnerability on roadways, it does not provide sufficient detail to actually prioritize bridge and roadway seismic retrofits on a given highway facility. The engineering and site evaluations will determine the actual needs for and costs of bridge and roadway seismic retrofit projects.

Identifying funding and implementing seismic lifelines priorities will be an ongoing part of the Highway Division's work for many years to come. The OSLR enables an approach that can be expedited or done incrementally over time. The Seismic Options Report addresses general questions about the kinds of work that need to be done and the economic value of doing that work. It is the intent of this combined effort to position the state to develop an increasingly resilient highway system in an efficient and strategic manner.

Future Enhancements to the State Risk Assessment

Climate Change

<Place holder for Climate Change Enhancements in next Plan update>

New Risk Assessment Methodology

During the 2012 Oregon NHMP update process it was realized by the state that there no standardize statewide risk assessment methodology is being used across all hazards— each hazard lead uses a different method to assess risk. This is due in part to the fact that "many state agencies do not have the tools and/or resources to conduct a full risk assessment. Likewise, most agencies do not maintain existing statewide risk assessment data" as identified in Task 5 of the Mid-Planning Alterations to the 2012 work plan. In response, the state allocated remaining federal funds from DR-1733 to support initial stages of the development of a standardized risk assessment model.

Beginning in March 2013, Oregon's Interagency Hazard Mitigation Team (IHMT) established a Risk Assessment Sub-Committee (RAS-C) that worked in partnership with faculty and staff from the University of Oregon's Department of Geography, InfoGraphics's Lab and Oregon Partnership for Disaster Resilience (OPDR) to develop a new risk assessment model concept. When fully developed and implemented, the model will provide a standardized way to assess vulnerability to natural hazards in Oregon thereby allowing the state to better identify where to strategically target mitigation resources. This initiative was facilitated by the Department of Land Conservation and Development (DLCD).

The RAS-C convened a total of five times from March to August to develop a risk assessment methodology that 1) meets federal requirements, 2) draws from the strengths of existing methods and 3) addresses Oregon's unique priorities. The committee took a four-pronged approach to developing a new risk assessment model. Phase One involved the review of natural hazard risk assessment methodologies found in academic literature and in other SNHMPs. In Phase Two, the UO team developed a proposed risk assessment model concept drawing from the strongest elements of the literature review and other research. While this phase focused heavily on adapting Susan Cutter's Social Vulnerability Index (SoVI), a key driver was the development of a framework tailored toward Oregon that could address key shortcomings identified in Cutter and other models. In addition, the model incorporates state priorities identified by the RAS-C. Phase Three involved testing the feasibility of the proposed model. Finally, in Phase Four, the UO team developed a timeline, work plan and budget in an effort to identify the resources needed to fully develop the risk assessment model and interface. The proposed three-year budget is roughly $600,000, which includes UO staff and resources.

This budget does not consider state time and resource needs, including, but not limited to, a high level of interagency collaboration to identify and classify hazard and vulnerability data, testing, and implementing the model. Notably, state resource needs will ultimately have to be identified and supported through funding and technical support to fully realize this model.

At this time, further development of the new model is pending funding. The RAS-C continues to meet to discuss potential funding opportunities. Due to the considerable amount of funding and other resources needed to fully develop and implement the new risk assessment methodology, it is likely that its development will take place in phases over the course of the next few iterations of the Oregon NHMP. At the time this Plan was written, the following grant proposal that would support the development and testing of the social vulnerability and flood hazard elements of the new model has been submitted and is awaiting funding announcements.

Oregon's Social Vulnerability to Climate-driven Hazards

One step toward developing the new risk assessment model would be the implementation of the Oregon Social Vulnerability to Climate-driven Hazards Project. Three state agencies – the Oregon Health Authority (OHA), the Department of Geology and Mineral Industries (DOGAMI), and the Department of Land Conservation and Development (DLCD) – and the University of Oregon will collaborate to complete this work.

This project will combine social vulnerability data, climate data, and natural hazard data to produce a decision support tool identifying risks to vulnerable populations and future flooding hazards. This partnership will 1) develop and refine an index of social vulnerability to climate change at the census-tract level, 2) develop a new climate-induced flood hazard data layer for one pilot watershed, and 3) combine the two data sets to analyze vulnerability to flooding. The information developed in this project will be used to inform the update of a Local Natural Hazard Mitigation Plan (LNHMP) in the pilot watershed.

Furthermore, the Oregon refined index of social vulnerability (at the census tract level) developed in this project will be used to further develop and test the social vulnerability element of the state's new risk assessment model. Testing the new risk assessment model will provide the state with a better understanding of the inter-agency data sharing and collaboration resources needed to fully realize the new model.

This project is pending funding from a National Oceanic and Atmospheric Administration (NOAA) - Climate Program Office (CPO) - Climate and Societal Interactions (CSI) - Sectoral Applications Research Program (SARP): Climate Extreme Event Preparedness, Planning, and Adaptation grant. Grantee announcement are scheduled for Spring 2014. Pending NOAA funding, this project is projected to be implemented August 1st, 2014 - July 31, 2016.

Cultural Resources

<Place holder for Cultural Resources Enhancements in next Plan update>

2015 OREGON NHMP UPDATE

Interagency Hazard Mitigation Team

Thursday, April 17, 2014

REQUIREMENTS

- Link State Goals and Mitigation Actions to the Risk Assessment
- Link local plans with the State Plan.
- Prioritize Mitigation Actions

AGENDA

- Risk Assessment, Goals, Mitigation Actions
- State & Local Goals
- State Mitigation Capability
- Prioritized Mitigation Actions
- Project Schedule
- Next Steps

RISK ASSESSMENT → GOALS → ACTIONS

RA MESSAGES	GOALS	ACTIONS
A. Wide-ranging hazard data C. Related hazards present collaboration opportunities	G1: Protect life G2: Minimize property damage, infrastructure and service disruption	5. Improve methodology for developing data on drought. 6. Establish a program for studying winter storms.
B. No standardized statewide RA methodology D. Similarities/differences in local & state vulnerability assessments E. Facility data gaps	G3: Increase economic resilience G4: Protect the environment G7: Motivate others to mitigate through information and education G8: Eliminate development in hazard areas where risks cannot be mitigated	1. Analyze state/local vulnerability assessment similarities/differences. 2. State/local dialogue on vulnerability assessment. 3. Improve critical facility potential loss estimates. 4. Improve state facility data.

RISK ASSESSMENT → GOALS → ACTIONS

Goal 5:
Enhance and maintain state capability to implement a comprehensive statewide hazard loss reduction strategy.

Goal 6:
Document and evaluate Oregon’s progress in achieving hazard mitigation.

DECISIONS

1. Retain existing goals as written?
2. Add new mitigation actions?
   A. Analyze the similarities and differences between state and local vulnerability assessments.
   B. Schedule three opportunities for state/local dialogue on local vulnerability assessments in the next year to improve consistency and mutual understanding.

DECISIONS

2. Add new mitigation actions? *(continued)*

   C. Collaborate with local governments to improve the accuracy of potential loss totals by more accurately identifying critical/essential facilities and determining their property values.

   D. Improve state agency procedures for tracking data on state-owned and –leased buildings and critical/essential facilities.

DECISIONS

2. Add new mitigation actions? *(continued)*

   E. Develop an improved methodology for gathering data and identifying the communities most vulnerable to drought.

   F. Establish a program for studying winter storms and their impacts statewide. Install snowfall sensors throughout the state to develop annual snowfall data.

STATE AND LOCAL GOALS

STATE	LOCAL
1. Protect life.	36
2. Minimize property damage, infrastructure and service disruption.	35
3. Increase economic resilience.	20
4. Protect the environment.	30
5. Enhance and maintain state [local] capability to reduce losses.	6
6. Document and evaluate [local] progress in achieving hazard mitigation.	2
7. Motivate others to mitigate through information and education.	34
8. Eliminate development in hazard areas where risks cannot be mitigated.	1

STATE AND LOCAL GOALS

Local goal themes not reflected in state goals:

- Protecting/mitigating cultural resources
- Developing/enhancing partnerships and coordination among agencies at all levels of government
- Integrating NHMPs with other plans

DECISIONS

3. Add new goals?
   A. Minimize damage to historic and cultural resources.
   B. Increase communication, collaboration, and coordination among agencies at all levels of government to mitigate natural hazards.
   C. Integrate local NHMPs with comprehensive plans and implementing measures.

RISK ASSESSMENT → GOALS → ACTIONS

- Wide-ranging hazard data
- Goal 5: Enhance and maintain state capability to implement a comprehensive statewide hazard loss reduction strategy.
- Limited resources
- Actions currently weighted toward CH, EQ, FL, LS, TS and lighter on DRT, DS, VOL, WF, WI, WS

DECISIONS

4. Prioritize hazards prior to next update cycle?

MITIGATION ACTIONS: STATUS

Priority:

1. Level of Support (1 highest – 3 lowest)
2. Score (29 highest – 0 lowest)
3. Multi-hazard (11-2; Support; Score)
4. Each Hazard (1; Support; Score)

Ongoing, Removed: Existing groups; Not ranked

MITIGATION ACTIONS: TO DO

Lead agencies please: DEADLINE 4/30/14

- Review Priority Worksheet for errors and completeness, redundancy, and for SMARTness.
- Provide corrections, revisions for enhanced SMARTness, missing or necessary additional information, recommendations for moving actions to Ongoing or Removed.

PROCESS & SCHEDULE *(SUBJECT TO CHANGE)*

	APR	MAY	JUN	JUL	AUG	SEP	OCT
RISK ASSESSMENT DRAFT 2	X	X	X				
GOALS	X			X?			
MITIGATION ACTIONS	X			X?			
MITIGATION STRATEGY	X	X	X				
STATE/LOCAL CAPABILITY	X	X	X				
PLAN MAINTENANCE	X	X	X				
PLANNING PROCESS	X	X	X				
ENHANCED PLAN	X	X	X				
FINAL IHMT REVIEW				X			
FINAL REVISIONS & EDITING					X	X	
SUBMIT TO FEMA							X

PROCESS & SCHEDULE *(SUBJECT TO CHANGE)*

	OCT	NOV	DEC	JAN	FEB	MAR
FEMA REVIEW	X	X				
REQUIRED REVISIONS		X	X			
RESUBMIT				X		
FEMA APPROVAL PENDING ADOPTION				X		
STATE ADOPTION					X	
FEMA FINAL APPROVAL					X	DONE

NEXT STEPS

- Review state-level risk assessment and provide comments by April 30th.
- Review mitigation action workbook and provide final revisions by April 30th.
- Provide specific information as requested needed to complete the draft Plan by June 30th.

Questions?

THANK YOU!

Oregon
John A. Kitzhaber, M.D., Governor

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Salem, Oregon 97301-2540
Phone: (503) 373-0050
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April 11, 2014

TO: Oregon State Interagency Hazard Mitigation Team (IHMT)

FROM: Marian Lahav, Natural Hazards Planner, DLCD

RE: April 17, 2014 IHMT Meeting:
2015 Oregon Natural Hazards Mitigation Plan (NHMP) Update
Plan Goals and Mitigation Actions

One of the federal requirements for a State NHMP is that the goals must be linked to the risk assessment. The goals then link the risk assessment to the mitigation actions. During the Plan update process, the goals must be assessed and either validated or revised.

At this point in the process we have a draft state-level risk assessment that characterizes the hazards and their impacts, and identifies the regions most vulnerable to each hazard. It also quantifies potential losses to state-owned and –leased buildings and critical/essential facilities in terms of property values, and identifies critical/essential facilities that are not state-owned or –leased in hazard areas. An analysis of the impacts of seismic events on identified transportation lifelines is also part of the risk assessment. Soon we will also have a regional risk assessment providing similar analysis at the local level.

This memo reviews the links between Oregon NHMP goals mitigation actions, the draft state-level risk assessment, and local NHMP goals. The IHMT will use this review to decide whether to retain the goals as currently written or revise them. The IHMT will also decide whether to add mitigation actions based on the draft risk assessment, and whether to prioritize hazards for the next Plan update cycle. Staff recommends adding three new goals, adding six mitigation actions, and prioritizing hazards in the next plan.

2012 Oregon NHMP Goals

GOAL 1 Protect life and reduce injuries resulting from natural hazards.
GOAL 2 Minimize public and private property damages and the disruption of essential infrastructure and services from natural hazards.
GOAL 3 Increase the resilience of local, regional, and statewide economies.
GOAL 4 Minimize the impact of natural hazards while protecting and restoring the environment.
GOAL 5 Enhance and maintain state capability to implement a comprehensive statewide hazard loss reduction strategy.
GOAL 6 Document and evaluate Oregon's progress in achieving hazard mitigation.
GOAL 7 Motivate the public, private sector, and government agencies to mitigate against the effects of natural hazards through information and education.
GOAL 8 Eliminate development within mapped hazardous areas where the risks to people and property cannot be mitigated.

Link between the Risk Assessment and the Goals of the Oregon NHMP

The purpose of the risk assessment is to identify and characterize Oregon's natural hazards, determine which jurisdictions are most vulnerable to each hazard, and estimate potential losses to vulnerable structures and infrastructure and to state facilities from those hazards. The risk assessment helps the state identify the most vulnerable jurisdictions and strategically target mitigation resources.

The information in the draft state-level risk assessment speaks directly to protection of life and property, infrastructure and services, and local, regional, and state economic resilience, the topics of Goals 1, 2, and 3. The vulnerability assessments for each hazard and the potential loss estimates highlight the importance of informing and educating citizens about the risks and what they can do to reduce potential losses, including eliminating development where risks cannot be mitigated, the topics of Goals 7 and 8. Environmental stewardship, the topic of Goal 4, plays a role in mitigating some hazards, and must be considered in designing mitigation projects. These are clear connections between the information in the risk assessment and the existing goals.

Goals 5 and 6 are more administrative in nature, focusing on the state's ability to implement the Plan, and document and evaluate progress in achieving mitigation.

Staff suggests that no changes are necessary to improve linkages between the risk assessment and the existing Oregon NHMP Goals. If the messages of the risk assessment change substantively once the regional risk assessment is developed, the goals will be revisited.

Link between the Goals in the Oregon NHMP and Goals in Local NHMPs

Local NHMPs are to be coordinated with and linked to the state NHMP. Plan goals offer one avenue for making that linkage with local NHMPs. A preliminary review of county-level NHMPs in Oregon indicates that while some state and local NHMP goals are shared (e.g., protection of life and property, enhancing government's ability to implementation the plan), local plans contain other goals the IHMT may want to adopt to better align state and local visions for hazard mitigation. Suggestions for new goals:

1. Minimize damage to historic and cultural resources.

2. Increase communication, collaboration, and coordination among agencies at all levels of government to mitigate natural hazards.

3. Integrate local NHMPs with comprehensive plans and implementing measures.

Link from the Risk Assessment, through the Goals, to the Mitigation Actions

Risk Assessment
The information in the risk assessment also supports these statements:

A. Much more data is available for some hazards than others, resulting in a more robust risk analysis for the more data-rich hazards.

B. There is a clear need to develop a statewide standardized risk assessment methodology across all hazards.

C. Similarities and differences between state and local level vulnerability assessments have not been analyzed. Some state and local vulnerability assessments are quite consistent, while others are starkly inconsistent. Communication and education among state and local staff responsible for assessing vulnerability would improve understanding and consistency.

D. Several hazards are related to one another through cause and effect (e.g., earthquakes and tsunamis, floods and landslides, drought and wildfires) or through shared drivers (e.g., El Nino Southern Oscillation (ENSO)), indicating opportunity for increasing interagency collaboration and efficiencies in research and mitigation activities.

E. Some state-owned or –leased buildings or critical/essential facilities and their contents cannot be accurately identified using available state data. Property values are not available for critical and essential facilities that are not state-owned or –leased. Local knowledge could be helpful in improving the state data by more accurately identifying buildings and their contents and determining which buildings and critical/essential facilities should be prioritized for mitigation. The state data could be useful at the local level as well. This opportunity for state and local collaboration could improve risk assessments and loss estimates at both levels.

Goals

These statements address issues covered by a number of the Plan goals (Goals 1, 2, 3, 7, 8). In particular, they raise an important question concerning Goal 5, the state's capability to implement a comprehensive statewide hazard loss reduction strategy. The State currently recognizes eleven hazards, obligating it to address each one, and strives to do so as fully and equitably as possible. Due to staffing, funding, data availability, access to expertise, or other reasons, some hazards cannot be addressed to the same extent as others. Staff suggests that prior to the next Plan update cycle, the IHMT prioritize hazards allowing resources to be strategically targeted.

Mitigation Actions

These statements also lead to recommended mitigation actions:

1. Analyze the similarities and differences between state and local vulnerability assessments.

2. Schedule three opportunities for state/local dialogue on local vulnerability assessments in the next year to improve consistency and mutual understanding.

3. Collaborate with local governments to improve the accuracy of potential loss totals by more accurately identifying critical/essential facilities, and determining their property values.

4. Improve state agency procedures for tracking data on state-owned and –leased buildings and critical/essential facilities.

Further, specific recommendations in the risk assessment suggest these new mitigation actions:

5. Develop an improved methodology for gathering data and identifying the communities most vulnerable to drought.

6. Establish a program for studying winter storms and their impacts statewide. Install snowfall sensors throughout the state to develop annual snowfall data.

Summary of Action Requested

Based on the information in the draft state-level risk assessment, the Oregon NHMP goals remain valid and require no revision. However, to improve coordination and linkage with local NHMPs, staff suggests the IHMT add three new goals. Further, staff suggests adding mitigation actions to address information and recommendations in the draft risk assessment. Finally, staff suggests that the IHMT prioritize hazards for the next Plan update.

Should these goals be added?

Y/N 1. Minimize damage to historic and cultural resources.

Y/N 2. Increase communication, collaboration, and coordination among agencies at all levels of government to mitigate natural hazards.

Y/N 3. Integrate local NHMPs with comprehensive plans and implementing measures.

Should these mitigation actions be added?

Y/N 1. Analyze the similarities and differences between state and local vulnerability assessments.

Y/N 2. Schedule three opportunities for state/local dialogue on local vulnerability assessments in the next year to improve consistency and mutual understanding.

Y/N 3. Collaborate with local governments to improve the accuracy of potential loss totals by more accurately identifying critical/essential facilities, and determining their property values.

Y/N 4. Improve state agency procedures for tracking data on state-owned and –leased buildings and critical/essential facilities.

Y/N 5. Develop an improved methodology for gathering data and identifying the communities most vulnerable to drought.

Y/N 6. Establish a program for studying winter storms and their impacts statewide. Install snowfall sensors throughout the state to develop annual snowfall data.

Should the IHMT prioritize hazards for the next Oregon NHMP update cycle?

2012 Oregon Natural Hazard Mitigation Plan

GOALS

GOAL 1 Protect life and reduce injuries resulting from natural hazards.

GOAL 2 Minimize public and private property damages and the disruption of essential infrastructure and services from natural hazards.

GOAL 3 Increase the resilience of local, regional, and statewide economies.

GOAL 4 Minimize the impact of natural hazards while protecting and restoring the environment.

GOAL 5 Enhance and maintain state capability to implement a comprehensive statewide hazard loss reduction strategy.

GOAL 6 Document and evaluate Oregon's progress in achieving hazard mitigation.

GOAL 7 Motivate the public, private sector, and government agencies to mitigate against the effects of natural hazards through information and education.

GOAL 8 Eliminate development within mapped hazardous areas where the risks to people and property cannot be mitigated.

HAZARDS

1. Coastal Hazards
2. Drought
3. Dust Storms
4. Earthquakes
5. Flooding
6. Landslides
7. Tsunamis
8. Volcanoes
9. Wildfire
10. Wind Storms
11. Winter Storms

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3	Action Item			Goal									Hazard												Integrated	Level of Support	Score	Implementation				
4	2012 #	Statement	Description	1 - Protect Life	2 - Protect Property	3 - Inc Ec Resilience	4 - Protect Env	5 - Enh OR Capability	6 - Evaluate Progress	7 - Info & Ed	8 - Elim Haz Area Dev	# Goals	Coastal Hazards	Drought	Dust Storms	Earthquakes	Floods	Landslides	Tsunamis	Volcanic Hazards	Wildfires	Windstorms	Winter Storms	# Hazards	Other Initiative	1 = Likely by 3/2018 2 = Not sure 3 = Unlikely by 3/2018	Score ≈ Benefit/Cost	Lead	Support	Potential Funding Source(s)	Target Completion Date	Status
5	**Revised CI-1A**	Complete statewide hazard identification: • Earthquakes • Tsunamis • Volcanoes • Flooding • Landslides • Coastal Hazards • Wildfire • Drought • Dust Storms • Wind Storms • Winter Storms	Complete hazard identification and characterization, including in terms of probabilities: • Coastal Hazards: Identify the coastal hazards, including rate and amount of movement, in terms of probabilities. • Drought: Identify the drought hazards statewide, including in terms of probabilities. • Dust Storms: Identify the dust storm hazards statewide, including in terms of probabilities. • Earthquakes: Identify statewide liquefaction susceptibility, lateral spreading susceptibility, co-seismic landslide susceptibility, soft soils and basins that amplify ground shaking, and active faults. • Flooding: Identify the flooding hazards statewide, in terms of probabilities. • Landslides: Identify the landslide hazards statewide, including rate and amount of movement, in terms of probabilities. • Volcano: Identify the volcanic hazards statewide, including in terms of probabilities. • Windstorms: Identify the wind storm hazards statewide, including in terms of probabilities. • Winter Storms: Identify the winter storm hazards statewide, including in terms of probabilities.	X	X	X				X	X	5	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Resilience Plan; Statewide Planning Goal 7; NFIP; Risk MAP; Oregon Climate Change Adaptation Framework	**1**	**29**	IHMT Agencies			2015	
82	**Revised CI-1L**	Complete statewide risk assessment: • Earthquakes • Tsunamis • Volcanoes • Flooding • Landslides • Coastal Hazards • Wildfire • Drought • Dust Storms • Wind Storms • Winter Storms	Assess the exposure, their vulnerabilities and estimate damage and losses. Exposure could include schools, emergency facilities, water and waste water, dams and levees, transportation, telecommunications and the energy sector.	X	X	X				X	X	5	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Resilience Plan, NFIP, Risk MAP, Oregon Climate Change Adaptation Framework	**1**	**29**	IHMT Agencies			2015	
90	**Revised CI-1M**	Complete statewide risk prioritization: • Earthquakes • Tsunamis • Volcanoes • Flooding • Landslides • Coastal Hazards • Wildfire • Drought • Dust Storms • Wind Storms • Winter Storms	Identify and then prioritize the highest risk issues for each hazard.	X	X	X				X	X	5	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Resilience Plan, NFIP, Risk MAP, Oregon Climate Change Adaptation Framework	**1**	**29**	DOGAMI, ODF, OWRD, OEM, ODOT			2015	
94	**Revised CI-1N**	Complete statewide resilience initiatives: • Earthquakes • Tsunamis • Volcanoes • Flooding • Landslides • Coastal Hazards • Wildfire • Drought • Dust Storms • Wind Storms • Winter Storms	Implement measures to improve the reliability of critical services	X	X	X			X		X	5	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Resilience Plan, NFIP, Risk MAP, Oregon Climate Change Adaptation Framework	**1**	**29**	IHMT Agencies			2018	

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12	**Revised EO-9**	Develop and fund a legislative package for general funds or lottery funds to match federal funding for local hazard mitigation planning, including additional funds for DLCD Technical Assistance Grants.	Continue – and enhance where possible – state technical and planning grant assistance to cities and counties for addressing issues associated with local hazards.	X	X	X	X	X		X	X	7	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Local Disaster Assistance Loan and Grant Account. This account addresses the need for local match for federal funding of projects, but not planning.	**1**	**28**	DLCD			2015	
61	**NEW MP-10A**	Create a "Clearinghouse" for natural hazards data	Emergency responders and community planners alike need to know where to find the best and most current natural hazards data that is available. This project: - Establishes a single point of online access to reliable data and information about natural hazards; - Develops, in conjunction with DAS GEO, a "portal" to distribute this data; - Provides an ongoing inventory and assessment of existing natural hazards data; and - Creates a central library for natural hazard risk assessments.	X	X			X		X	X	5	X	X	X	X	X	X	X	X	X	X	X	11	Risk MAP; RiskPlan; Framework Implementation Teams; OEM's Master Dataset; LHMPs; Governor's interagency collaboration initiative; Goal 7	**1**	**23**	DLCD	DAS, DEQ, DOGAMI		2016	
100	**REVISED EO-39A**	Enroll 3 coastal communities in the Tsunami Ready Program each year.	The Tsunami Ready Program is a program sponsored by the National Weather Service that is designed to provide communities with incentives to reduce their tsunami risk. Cannon Beach was the first community for Oregon. Under a proposed plan through the National Tsunami Hazard Mitigation Program (NTHMP), three communities per year will be added to the rolls of the program. This program is currently evolving through a review process being carried out by the NTHMP National Coordinating Committee. OEM is the primary point of contact for more information about the Tsunami Ready Program.	X	X	X				X		4							X					1	Oregon Resilience Plan	**1**	**23**	OEM	DOGAMI		2018	
7	**LP-2***	Complete a hazard mitigation policy legislative needs assessment	The Oregon NHMP contains a number of specific policy recommendations. In addition, the state of Oregon maintains a number of policies related to natural hazards and the mitigation thereof. It is unclear at this time what legislative action may be needed in order to fully implement existing and proposed mitigation actions. The State IHMT has identified greater interaction with the legislature as a top priority in the coming years. As a first step, the State IHMT recommends completing an assessment of the potential legislation needed to implement hazard mitigation policies. The assessment shall review existing and proposed policies and develop a list of potential legislative priorities.	X	X	X	X	X	X	X	X	8	X	X	X	X	X	X	X	X	X	X	X	11		**1**	**22**	OEM			2015	
48	**NEW MP-5B**	Through FEMA's Risk MAP program, update 1,000 miles of streams with lidar-based flood mapping	FEMA's Risk MAP program funds revisions for Flood Insurance Studies and Flood Insurance Rate Maps. The State should focus on updating these products so they are based on high quality topographic data (e.g. lidar). The State should continue to pursue Risk MAP funds primarily for this purpose.	X	X					X	X	4					X						1	NFIP	**1**	**22**	DLCD, DOGAMI			2016	

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38	**NEW MP-15A**	Implement the Rapid Assessment of Flooding Tool	The RAFT (Rapid Assessment of Flooding Tool) has been funded by the US Army Corps of Engineers (USACE) through FY 14 for $115,000. The goal of the RAFT is to take real time flood forecasts and relate them to flood frequency curves from FEMA, USGS, and OWRD. This will help decision makers prioritize real-time flood fighting assistance. The tool will also incorporate other important decision-influencing factors, possibly including structures in danger of flooding, population affected, and likelihood of levee failure. The RAFT is intended to work in concert with and feed data to other tools, such as the RAPTOR. The tool is in very early development, and the scope and schedule are under development. For the remainder of the year, the RAFT team will focus on developing the scope and schedule, identifying data needs, and tasking members to track down data. The development of the RAFT will pick up more steam in FY 14, when more labor resources are available from the Corps. Once RAFT is developed, OEM will have operational oversight when the ECC is activated.	X	X							2					X							1	Silver Jackets	**1**	**22**	DLCD	OEM, DOGAMI, OWRD		2016	
33b	**NEW EO-73**	Form an Oregon Landslide Workgroup.	An Oregon Landslide Workgroup will be created to prioritize areas for new mapping projects, to promote landslide hazard awareness through education & outreach, to develop and influence policy at the federal state, and local levels, and to assist in response & recovery efforts during disasters.	X	X	X		X		X		5						X						1		**1**	**22**	DOGAMI			2015	
40a	**NEW EO-74**	Upgrade the Oregon Landslide Warning System.	The current warning system needs updating to include rainfall thresholds from local rainfall gauges. A permanent real-time website will be constructed to show the areas under a landslide warning that will include guidance on what people should do to help protect their life and property from a landslide.	X	X			X		X		4						X						1		**1**	**22**	DOGAMI			2015	
27	**LU-1***	Develop model risk reduction techniques and ordinances for landslide-prone communities	Techniques can involve requiring geological or geotechnical studies for new development, storm water control for neighborhoods on hillslopes, strict land use ordinances for active landslides, working with infrastructure operators to increase reliability of services after storms, and more.	X	X						X	3						X						1	Statewide Planning Goal 7	**1**	**22**	DLCD	DOGAMI		2015	
31	**REVISED LU-8A**	Develop guidance for local governments on how to use Goal 7 together with other pertinent Statewide Land Use Planning Goals to classify lands subject to natural hazards in the buildable lands inventory and adjust urban growth boundaries in a manner that minimizes or eliminates potential damage to life, property, and the environment while continuing to provide for efficient development patterns.	Goal 7 discourages new development in areas subject to natural hazards. Goal 14 and other Statewide Land Use Planning Goals encourage development within urban growth boundaries. Local governments need guidance on how to classify lands subject to natural hazards in their buildable lands inventories and adjust urban growth boundaries to protect life, property, and the environment from natural hazards while providing for efficient development patterns within urban growth boundaries. This guidance will assist local governments in integrating local natural hazard mitigation plans with comprehensive plans.	X	X	X	X				X	5	X	X	X	X	X	X	X	X	X	X	X	11	Statewide Planning Goals	**1**	**21**	DLCD			2018	
48b	**NEW MP-34**	Identify communities along the Oregon coast that should consider vertical evacuation structures and improved evacuation routes due to evacuation constraints.	Use the anisotropic path modeling to measure the time needed to evacuate all parts of the maximum-considered Cascadia tsunami inundation zone in order to evaluate the need for vertical evacuation structures and improvements in evacuation routes.	X		X				X		3	X			X			X					3	Oregon Resilience Plan	**1**	**21**	DOGAMI			2015	
33a	**NEW LU-20**	Provide guidance to the maritime community for evacuation response for local Cascadia and distant tsunami events.	Tsunami model data including minimum flow depths and maximum flow velocities, will be analyzed to determine port-specific maritime guidance.	X						X		2	X			X			X					3	Oregon Resilience Plan	**1**	**21**	OEM, DOGAMI	DLCD		2015	
77	**NEW EO-37C**	Produce new lidar-based flood hazard maps - - **ONGOING?**	Through FEMA or otherwise.	X	X	X				X	X	5					X							1	NFIP, Risk MAP	**1**	**21**	DOGAMI	DLCD		2018	
60	**NEW EO-68**	Create an informational website for the new Base Flood Elevation Determination Service.	Create website that describes the state's base Flood Elevation Determination Service. Website will include brochure, pricing, map of completed determinations, and data clearinghouse for completed determinations.	X	X					X	X	4					X							1	NFIP, Risk MAP	**1**	**21**	DOGAMI	DLCD		2015	

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106	**NEW MP-37**	Develop new standardized risk assessment methodology across all hazards, at the state and local levels.	Oregon does not have a clear and common methodology to identify the most vulnerable populations across all hazards at the state and local levels. In 2013, the IHMT RAS-C in partnership with the OPDR and the InfoGraphics Lab at the University of Oregon developed a model concept, 3-year workplan and budget. Pending funding, this model could be fully developed between 2014-2017 and then be used to inform the 2018 OR NHMP. Upon full development, the model will allow state and local governments to better identify where to strategically target mitigation resources.	X	X							2	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Resilience Plan, NFIP, Risk MAP, Oregon Climate Change Adaptation Framework, Oregon Health Authority	**1**	**20**	DLCD	DEQ, OEM, DOGAMI, UO, Business Oregon, FEMA		2017	
108	**NEW CI-~~26~~27**	Complete a Climate Change Vulnerability Assessment and Adaptation Pilot for north coast highways.	The goal of ODOT's pilot is to conduct a regional vulnerability assessment and prepare options for adaptation actions and priorities. In coordination with ODOT Maintenance, the project will collect and map vulnerability and risk data based on climate science, asset conditions, and known and anticipated natural hazards. Hazard sites will be selected within a study corridor for more detailed analysis. Based on engineering and technical reviews, adaptation measures will be developed for vulnerable infrastructure and assembled into a coastal adaptation implementation plan. ODOT received a Federal Highway Administration grant to conduct the project, scheduled for completion in fall 2014.	X	X							2	X			X	X	X	X					5	Oregon Resilience Plan, NFIP, Risk MAP, Oregon Climate Change Adaptation Framework, Oregon Health Authority	**1**	**20**	ODOT			2015	
83	**NEW EO-66**	Refine coastal erosion risk mapping for Tillamook County and its cities to utilize a fully probabilistic approach.	Revise coastal erosion risk mapping and analysis for Tillamook County, and cities within the County, to utilize a fully probabilistic approach. Probablistic modeling approaches will be used to better address uncertainty and allow local and state hazard managers to use the information to better manage uses based on the relative risks. This will assist DLCD/DOGAMI to increase assistance to local governments in developing inventories based on sound technological research and in incorporating this information into their coastal management programs.	X	X					X	X	4	X											1	Statewide Planning Goal 7	**1**	**20**	DOGAMI	DLCD		2015	
11	**NEW LP-24**	Request LCDC to include Local Natural Hazard Mitigation Planning as a priority for DLCD Technical Assistance Grant awards to use as match for federal funds when available.	The Land Conservation and Development Commission (LCDC) awards Technical Assistance Grants to local governments to support local planning efforts in certain priority land use topic areas which at this time do not include natural hazard mitigation. If LCDC were to include natural hazard mitigation planning as a priority topic area, local governments would have the opportunity to compete for funding and the state would be better able to provide technical assistance for natural hazard mitigation planning.	X	X	X	X	X		X	X	7	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Local Disaster Assistance Loan and Grant Account. This account addresses the need for local match for	**1**	**19**	DLCD			2015	
28	**LU-2***	Develop a process for implementing revised elements of Goal 7	Goal 7 currently includes a process for notification to local governments of new hazard information. It also requires that local governments review any new hazard information brought to their attention and determine if a local land use response is needed. (LCDC adopted the revised goal in 2001. The revised Goal 7 became effective in June 2002.) Since the Goal's revision, several studies and reports on natural hazards have been published and disseminated. The process for determining which information should trigger local land use evaluations, however, remains untested.DLCD will implement the process, review the results, and determine whether any changes are necessary. This action is necessary to ensure that local governments evaluate and respond to information regarding natural hazards within their communities.	X	X						X	3	X	X	X	X	X	X	X	X	X	X	X	11	Statewide Planning Goal 7	**1**	**19**	DLCD	DOGAMI		2015	
102	**REVISED CI-14A**	Develop plans for rapid mobilization of inspectors for post disaster facility inspection.	Create rapid communication networks to effectively alert necessary inspectors when disasters occur. Work with OEM, local government building officials, and emergency planners to establish an effective process for assigning inspection teams to needed areas and educating local governments regarding the circumstances and process for initiating BCD and state involvement.			X		X				2	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Resilience Plan	**1**	**19**	BCD, OEM			2015	
45	**NEW EO-65**	Update the inventory of shoreline protective structures.	Update the inventory of existing and new coastal engineering (shore protection) structures on the Oregon Coast.	X	X							2	X											1		**1**	**19**	DLCD			2015	

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9	**REVISED LP-12**	Work with Business Oregon to introduce in 2015 legislation allowing reconstruction of structures that cannot feasibly be retrofitted.	Revise SRGP legislation or develop an alternate funding mechanism to help replace schools and emergency facilities that are too structurally deficient for cost-effective retrofit and need to be replaced instead. This would also include structures in the "local" tsunami inundation zone that should not be retrofit in-place but, rather, rebuilt on natural high ground.	X	X	X						3				X			X					2	Oregon Resilience Plan	**1**	**19**	OEM			2015	
98	**REVISED EO-1*A**	Add at least one jurisdiction, with emphasis on coastal jurisdictions, to the Community Rating System (CRS) program during the life of each Oregon NHMP.	The CRS, part of the NFIP, is a program that rewards communities for going above and beyond the minimum requirements of the NFIP in minimizing potential losses due to flooding. Participating in the CRS benefits the jurisdiction with extra flood protection and benefits property owners by lowering flood insurance rates. The state will continue its efforts to implement CRS in local communities. See the CRS Information Center at: http://training.fema.gov/EMIWeb/CRS/ for more information. Each year DLCD conducts community assistance visits in an average of five NFIP communities. During this process, qualified jurisdictions will be encouraged to participate in CRS or strengthen CRS ratings. DLCD will also create a "pathway to CRS" schedule for each jurisdiction for which it conducts a community assistance visit.	X	X	X				X		4					X							1	NFIP	**1**	**19**	DLCD			2018	
43	**NEW LP-22**	Update the state's Peak Discharge Estimation Program.	Peak discharge estimation tools can help determine the magnitude and frequency of floods. The state's program provides engineers and land managers with the information needed to make informed decisions about development in or near watercourses. The Peak Discharge Estimation Program is based on a modified version of the U.S. Geological Survey's "Bulletin 17b." The U.S. Geological Survey is in the process of updating this bulletin. OWRD's methodology will need to be brought up to date to reflect these recent findings.	X	X							2					X							1	Integrated Water Resource Strategy	**1**	**19**	OWRD			2016	
97	**REVISED LP-19A**	Develop and implement flood protection standards for state-owned and -leased buildings.	According to the Senate Bill 814 Task Force (Oregon Legislature, 1997 Session), there is a need to develop and effectively implement a strict standard governing the siting, construction, and leasing of buildings occupied by state agencies in flood-prone areas.	X	X							2					X							1	NFIP	**1**	**19**	DAS	DLCD		2015	
25	**CI-19**	Develop evacuation plans for ports and harbors	Ports and harbors are the haven for commercial and recreational fishing and recreational boating industries. They are often the major centers of economic activity in coastal communities that have bays. To protect the vessels from tsunami damage requires a unique evacuation plan for both distant and local tsunamis. The plans should be integrated with community evacuation plans. The Oregon State University Extension Sea Grant Program has identified this as a major issue in their pilot project in Yaquina Bay. Their project is titled *Reducing Earthquake and Tsunami Hazards in the Pacific Northwest Ports and Harbors.* For distant tsunami events and storm surge events that can occur during any winter, evaluate potential port and harbor mitigation retrofit projects that protect and strengthen floating and anchored infrastructure such as piers, bulkheads and landings.	X	X	X						3	X			X			X					3	Oregon Resilience Plan, OSU Extension Sea Grant Program	**1**	**18**	OEM, DOGAMI	DLCD		2015	
19	**REVISED LP-10**	Incorporate text addressing hazard mitigation into natural resource agencies' guidance and process documents focusing on environmental quality to ensure that natural resources are protected in the design and construction of hazard mitigation projects.	Government and private nonprofit agencies in Oregon must address complex issues associated with flood hazard mitigation in the context of clean drinking water, riparian habitat, watershed health, fisheries, wetlands protection, and overall environmental quality. An important plan related to this effort is the *Oregon Plan for Salmon and Watersheds.* Solutions require multi-agency and intergovernmental efforts. While the decisions and projects will vary with each disaster, the state will continue its efforts to develop appropriate policies and criteria to ensure that these are considered along with hazard mitigation needs. This includes guidance on large wood placement, restoration after flood events, and habitat-friendly methods to accomplish pre- and post-disaster hazard mitigation. Watershed assessments being completed around the state by local watershed councils will be used in the evaluation of flood hazards and floodplain processes.				X					1	X				X							2	Oregon Plan for Salmon & Watersheds	**1**	**18**	ODFW, DSL			2015	

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	Action Item			Goal									Hazard												Integrated	Level of Support	Score	Implementation				
2012 #	Statement	Description	1 - Protect Life	2 - Protect Property	3 - Inc Ec Resilience	4 - Protect Env	5 - Enh OR Capability	6 - Evaluate Progress	7 - Info & Ed	8 - Elim Haz Area Dev	# Goals	Coastal Hazards	Drought	Dust Storms	Earthquakes	Floods	Landslides	Tsunamis	Volcanic Hazards	Wildfires	Windstorms	Winter Storms	# Hazards	Other Initiative	1 = Likely by 3/2018 2 = Not sure 3 = Unlikely by 3/2018	Score ≈ Benefit/Cost	Lead	Support	Potential Funding Source(s)	Target Completion Date	Status
REVISED LU-17A	Integrate the GIS database of tsunami safe zones and assembly areas into local government databases.	Assist counties not only with how to integrate the data, but also how the data can be used for tsunami evacuation planning.	X						X		2	X						X					2	Oregon Resilience Plan	**1**	**18**	OEM	DOGAMI		2015	
Revised EO-10	Facilitate accessibility and use of the *Coastal Atlas* GIS resources. **- - ONGOING?**	Make the *Coastal Atlas* geographic information system (GIS) more useful for a wider audience, from local and state staff to interested citizens, by continuing to improve its data and tools, and providing training on how to access and use them.	X	X		X			X	X	5	X											1	Statewide Planning Goal 7	**1**	**18**	DLCD, OPRD			2016	
EO-22	Encourage the purchase of earthquake insurance **- - ONGOING?**	Unlike flood insurance, which is underwritten by the U.S. Government (through the National Flood Insurance Program), earthquake insurance is offered by private sector agents and generally "packaged" as a rider to a standard homeowner or business property insurance policy. For some people, the question should not be whether or not to purchase earthquake insurance, but rather, how much to buy. For others, the decision requires a risk assessment: how likely is an earthquake?; how much damage would it inflict on ones property?; and how much can one afford to lose? Earthquake insurance rates are determined differently by each insurance company and can vary widely depending on several rating factors. Generally, older homes cost more to insure than new homes. Wood homes get better rates than brick ones because they tend to withstand earthquake stresses better. Because earthquake insurance is a type of catastrophic coverage, most policies carry a high deductible; usually anywhere from 5% to 15% of the value of a house. It is recommended that state agencies, local governments, and private sector insurance companies do a better job of promoting the purchase of earthquake insurance.		X	X						2				X								1	Oregon Resilience Plan	**1**	**18**	DCBS-ID			2015	
NEW EO-1B	Strengthen the existing CRS rating of at least one jurisdiction, with emphasis on coastal jurisdictions, during the life of each Oregon NHMP.	The CRS, part of the NFIP, is a program that rewards communities for going above and beyond the minimum requirements of the NFIP in minimizing potential losses due to flooding. Participating in the CRS benefits the jurisdiction with extra flood protection and benefits property owners by lowering flood insurance rates. There are a number of measures a community can implement to obtain a CRS rating, and most communities do not implement them all. As a community implements more CRS flood protection measures, its CRS rating is strengthened, and the community is rewarded with better flood protection and lower flood insurance rates.	X	X	X				X		4					X							1	NFIP	**1**	**18**	DLCD			2018	
NEW EO-69	Establish a web page where building owners can register their interest in participating in acquisition programs for flood-damaged buildings. The on-line page complements OEM and DLCD's on-going prospective outreach to owners of identified Repetitive Loss and Severe Repetitive Loss buildings.	FEMA funds can be used to buyout repetitive loss and severe repetitive loss properties in the floodplain. The paperwork and process to achieve a buyout are lengthy and complex. First and foremost, a property owner must be willing to sell. Buyout funds could be more efficiently and effectively spent if willing sellers were identified and paperwork prepared before funds became available. This registry would augment the state's current outreach efforts, making it easy for willing sellers to identify themselves and for the state to prepare for and execute buyouts.	X	X	X				X		4					X							1	NFIP	**1**	**18**	DLCD, OEM			2015	
REVISED LU-3*	Provide technical assistance to local governments to help integrate hazard mitigation plans with local comprehensive plans.	Local NHMPs are often adopted as an appendix to the comprehensive plan or separately and are therefore in practice not used to their full potential. By assisting local governments in integrating the two plans, hazard mitigation will be more easily and meaningfully implemented in local land use planning practice. In late 2013, a pilot project to integrate the CIty of Madras's comprehensive plan and NHMP began, and is expected to be completed within a year. It is anticipated that more local jurisdictions will undertake this effort when updating their NHMPs or comprehensive plans.	X	X	X	X			X	X	6	X	X	X	X	X	X	X	X	X	X	X	11	Statewide Planning Goal 7	**1**	**17**	DLCD, OPDR			2015	
REVISED CI-4A*	Request and compile seismic and flood information for personnel-occupied buildings from other agencies and the university system.	Determine earthquake damage and losses expected to occur to the state owned building inventory including higher education buildings. Produce information to enable development of statewide priorities and strategies to guide mitigation of earthquake risk, to protect lives during an earthquake, and to preserve ongoing operations after an earthquake. Use accepted methods to determine building type, construction and occupancy, to estimate damage and losses due to various earthquake scenarios and probabilities relating to building codes.	X	X							2				X	X							2	Oregon Resilience Plan, NFIP	**1**	**17**	DAS-EAM	DOGAMI		2015	

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84b	**REVISED CI-4B***	Request seismic and flood information from landlords as part of analyzing potential leased spaces going forward in new leases and potential renewals.	Determine earthquake damage and losses expected to occur to the state owned building inventory including higher education buildings. Produce information to enable development of statewide priorities and strategies to guide mitigation of earthquake risk, to protect lives during an earthquake, and to preserve ongoing operations after an earthquake. Use accepted methods to determine building type, construction and occupancy, to estimate damage and losses due to various earthquake scenarios and probabilities relating to building codes.	X	X							2				X	X							2	Oregon Resilience Plan, NFIP	**1**	**17**	DAS-EAM	DOGAMI		2015	
84	**REVISED CI-4C***	Investigate/inventory DAS-owned buildings for seismic risk.	Determine earthquake damage and losses expected to occur to the state owned building inventory including higher education buildings. Produce information to enable development of statewide priorities and strategies to guide mitigation of earthquake risk, to protect lives during an earthquake, and to preserve ongoing operations after an earthquake. Use accepted methods to determine building type, construction and occupancy, to estimate damage and losses due to various earthquake scenarios and probabilities relating to building codes.	X	X							2				X								1	Oregon Resilience Plan	**1**	**17**	DAS-EAM	DOGAMI		2016	
78	**REVISED CI-7A**	LIDAR survey the State's ROW (rights of way), west of the Cascade Range, to determine where landslide potential exists.	The acquired information can improve critical infrastructure (CI) resilience in the face of landslide events, by providing useful information to planners, design professionals and decision makers prior to delivery system construction.	X	X	X				X	X	5						X						1	Statewide Planning Goal 7	**1**	**17**	DOGAMI	ODOT		2015	
57	**NEW EO-20B**	Achieve 100% state agency participation in the Great Oregon ShakeOut	Practicing to "Drop, cover, and hold" is critical in reducing injury and loss of life in the workplace and home during an earthquake. The more people practice the drill, the better they will respond to a real event. State agencies are setting an example by conducting a drill annually. The State of Oregon will have 100% State agency participation in the Great Oregon ShakeOut and will encourageschools and universities to participate.	X	X					X		3				X								1	Oregon Resilience Plan	**1**	**16**	OEM			2018	
55	**NEW EO-19B**	Host at least one workshop or other educational opportunity on a biennial basis in communities where a Volcano Coordination Plan has been adopted. **- - ONGOING?**	The State of Oregon will actively work to increase the public's knowledge of the volcano hazard in Oregon.	X	X					X	X	4								X				1		**1**	**16**	OEM			2018	
26	**NEW CI-22**	Fund and provide technical assistance for local governments to engage in evacuation route planning and project implementation.	After a Cascadia Subduction Zone earthquake, a tsunami could arrive within minutes. It is essential that residents and visitors be able to quickly move to high ground. Some evacuation planning is already underway. Local governments need funding and technical assistance to begin or continue to engage in evacuation planning.	X								1	X			X			X					3	OSSPAC, Statewide Planning Goal 7, ORS 455	**1**	**15**	OEM, DLCD, DOGAMI			2016	
42	**NEW LP-21**	Install real-time monitoring capabilities on state-operated stream gages **- - #/yr? all the rest by 20__?**	The availability of timely and accurate data from stream gages is essential for flood forecasting, for prediction of imminent flood hazards, and for response to flood emergencies. Today, 178 of the state's 229 stream gages provide real-time data. Upgrade the state's existing stream gaging network, with the goal of installing real-time capability on all remaining gages.	X	X							2					X							1	Integrated Water Resource Strategy; Silver Jackets	**1**	**15**	OWRD	ODF		2016	
103	**REVISED CI-21**	Implement better wayfinding solutions for tsunami evacuation. Create hardened and improved evacuation routes to include elevated safe areas above the level of modeled inundation.	After a Cascadia Subduction Zone earthquake, a tsunami could arrive within minutes. It is essential that residents and visitors be able to quickly move to high ground on foot. This requires clearly marked and safe routes that pedestrians are able to navigate even in dark and stormy weather. Where high ground is available, projects should be identified that will enable Oregon to establish new standards and guidelines for methods to harden and mark way-finding of tsunami evacuation routes to natural high ground. Where natural high ground is not within the expected evacuation time, evaluate the retrofit of existing facilities and/or construction of new facilities that rise above the level of tsunami inundation and can serve as safe haven refuges.	X						X		2	X			X			X					3	Oregon Resilience Plan	**1**	**14**	OEM, DOGAMI			2015	
95	**LP-15**	Develop incentive/subsidy program for retrofit of one and two family residences	Design a system of grants or tax credits to encourage homeowners to retrofit residences to minimize displaced post-earthquake shelter demand and reduce population loss during recovery.	X	X	X						3				X								1	Clean Energy Works; Portland City Council; Certified local contractors	**1**	**14**	OEM			2018	

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10	**NEW LP-23**	Request the legislature to fund the "State Disaster Relief Fund" immediately following a presidentially declared disaster or other disaster.	The State Disaster Relief Fund includes an account that can be used to fund local government and school district mitigation projects after a presidentially declared disaster. The legislature may authorize deposits to the account when requested.	X	X	X						3	X	X	X	X	X	X	X	X	X	X	X	11		**1**	**11**	OEM			2015	
6	**LP-1***	Review and re-establish State IHMT membership and member responsibilities	When first established, the State IHMT membership consisted largely of agency directors or other high level agency staff. Over time, agency interaction with and oversight of State IHMT activities has been delegated. In some instances, this has resulted in better connection with the individuals that are actually responsible for mitigation activities in the respective agencies. In other cases, such delegation has resulted in the loss of an overall understanding of mitigation activities occurring throughout individual agencies. Given the lack of dedicated resources at the agency level for participation in the State IHMT, a review and re-establishment of the State IHMT membership and member responsibilities based on current resource constraints is needed.	X	X	X	X	X	X	X	X	8	X	X	X	X	X	X	X	X	X	X	X	11	OSSPAC, OWEB	**2**	**23**	OEM			2017	
8	**LP-3***	Establish statutory authority for the State IHMT	Since its formation, the State IHMT has continued to play major roles in hazard mitigation activities, including the development of this hazard mitigation plan. There is strong agreement that the State IHMT is important, should be continued, and ought to be made permanent because it is the only state body focused on coordination of natural hazard mitigation. It is recommended that the State IHMT be formally established in Oregon statute.	X	X	X	X	X	X	X	X	8	X	X	X	X	X	X	X	X	X	X	X	11	OSSPAC	**2**	**23**	OEM			2017	
92	**NEW LU-19**	Develop a system for prioritizing and ranking state-owned critical facilities for mitigation.		X	X	X						3	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Resilience Plan	**2**	**23**	DOGAMI, DLCD, OEM	DAS-EAM		2016	
22	**EO-11**	Produce Coastal Development Handbook	Produce a *Coastal Development Handbook* that addresses coastal process and hazards, beach and shoreland public policy, buying oceanfront property [what to look for, what questions to ask], building on oceanfront property, choosing appropriate hazard mitigation techniques, and choosing and using geotechnical consultants and engineers.	X	X	X	X	X		X	X	7	X			X	X	X	X					5	Statewide Planning Goals 5 & 7	**2**	**22**	DLCD	DOGAMI		2017	
48c	**NEW MP-35**	Evaluate the impact of climate change on landslides.	The precipitation-triggered landslides will increase or decrease with changes in climate. Evaluation of this change will be important for the future of Oregon.	X	X						X	3						X						1	Oregon Climate Change Adaptation Framework	**2**	**22**	DOGAMI			2016	
107	**NEW MP-38**	Develop new climate-hazard data and a social vulnerability index; and integrate into local NHMPs.	There is high demand among various agencies for 1) fine-grained data on social vulnerability and 2) climate-induced hazard data. Furthermore, local decision makers lack tools to understand the drivers of vulnerability and the magnitude of disaster risk associated with climate change. OHA, DLCD, DOGAMI and UO have collaborated to create a NOAA grant proposal to develop 2 new data sets for Oregon: 1) a social vulnerability index for the entire State and 2) climate-induced flood data for one watershed. Both data sets will be at the census tract scale. The new data will be applied in one pilot watershed to inform a LNHMP update. This project will also further the development of the new risk assessment model that will inform the State and local communities more strategically target mitigation resources.	X	X							2	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Resilience Plan, NFIP, Risk MAP, Oregon Climate Change Adaptation Framework, Oregon Health Authority	**2**	**21**	OHA	DLCD, DOGAMI, UO		2017	
62	**NEW MP-10B**	Develop a multi-agency State of Oregon flood hazard website	Create one-stop data, information, and map clearinghouse for flood hazards. Website will be cooperative effort between authoritative data sources -- DLCD, DOGAMI, OEM, OWRD, and federal partners (FEMA, USACE, NWS, USGS).	X	X	X				X	X	5					X							1	NFIP, Risk MAP	**2**	**21**	DLCD, DOGAMI	OWRD		2016	
75	**EO-37**	Create new LiDAR-based Landslide Inventory and Susceptibility Maps, especially near population centers. **- - ONGOING?**	DOGAMI will create these maps in cooperation with local municipalities. Specific methods and priority locations are still to be determined.	X	X	X				X	X	5						X						1	Statewide Planning Goal 7	**2**	**21**	DOGAMI			2018	
21	**Revised EO-6A**	Update *Planning for Natural Hazards: Oregon Technical Resource Guide.*	*Planning for Natural Hazards: Oregon Technical Resource Guide* was published in 2000 and needs to be updated.	X	X	X	X	X		X	X	7	X	X	X	X	X	X	X	X	X	X	X	11	Statewide Planning Goal 7	**2**	**20**	DLCD, OPDR			2017	

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NEW CI-26	Continue to act upon opportunities to advance the State's lifeline mitigation investment practice. - - **ONGOING?**	Expand upon the State's mitigation investment practice by: (1) Supporting efforts by jurisdictions and transportation districts to develop mitigation policy and retrofit plans for lifeline assets and service facilities; (2) Continuing to advance design and maintenance standards and requirements for bridges and unstable slopes, transit, rail, ports, and priority lifeline airfields; (3) Developing a temporary bridge installation policy and standards; (4) Supporting research on retrofit methods and strategies for Cascadia subduction zone earthquake loads and tsunamis.	X	X	X						3	X			X	X	X	X					5	Oregon Highway Plan (OHP); The Oregon Resilience Plan	**2**	**20**	OEM, ODOT			2017	
NEW EO-72	Facilitate self sustaining outreach programs staffed by Community Emergency Response Teams (CERT) or CERT-like organizations in each coastal population center aimed at creating a culture of preparedness and response for both local Cascadia and distant tsunami events.	Nearly all coastal communities participated at some level over the last 4 years in implemention of outreach techniques tested in a 2005 pilot study of Seaside (#1 priority = door-to-door education; #2 priority = community evacuation drill; #3 = K-12 education supplemented by workshops targeted at specific user groups such as the lodging industry). Sustainability of these pilot programs needs to be measured, deficits identified and resolved (State facilitation and leadership needed).	X		X				X		3	X			X			X					3	Oregon Resilience Plan	**2**	**20**	OEM	DOGAMI		2016	
REVISED EO-13	Determine the effectiveness of the Emergency Alert System (EAS) in dust prone areas at providing timeline information to the traveling public about dangerous blowing dust conditions and make improvements if needed.	One of several ideas proposed following the Sept. 1999 accidents on Interstate 84 near Echo was to "put word out quickly" utilizing the Emergency Alert System (EAS) via area radio stations about dust storm potential, and especially about actual conditions that are interfering with visibility. This idea was in addition to ODOT's Highway Advisory Radio and related resources noted as success stories on pages DS-5 to DS-7. With regard to the Mid-Columbia Region, it was noted that Tri-Cities radio stations need to be included because many people driving through that area are listening to stations based in Washington State. ODOT and OSP have primary responsibility for activating the traffic advisory components of the dust storm response plan for the Mid-Columbia Region. The National Weather Service can also activate EAS from their forecast offices in Pendleton, Boise, Medford, and Portland. Many local emergency program managers can also activate the system.	X								1			X								1		**2**	**20**	OEM	ODOT, OSP		2017	
NEW MP-15B	Add at least three new flood inundation forecast points to the National Weather Service's Flood Inundation Mapping website and the USGS's Flood Inundation Mapper before 2018.	The National Weather Service Advanced Hydrologic Prediction Service (AHPS) has developed inundation mapping sites for various stream gage locations nationwide. Currently Oregon does not have any sites with inundation mapping. This is a useful emergency management tool for understanding potential inundation areas based on NWS forecasts. (National Weather Service: http://water.weather.gov/ahps/inundation.php; U.S. Geological Survey: http://wim.usgs.gov/fimi/)	X	X							2					X							1	National Weather Service, Silver Jackets	**2**	**19**	DOGAMI	OWRD		2017	
NEW MP-31	Support and implement the actions in the February 2013 Oregon Resilience Plan and recommended in the Oregon Resilience Plan Task Force's October 2014 report (SB33, 2013).	The Oregon Resilience Task Force was established by Senate Bill 33. It is tasked to facilitate a comprehensive and robust plan to implement the strategic vision and roadmap of the Oregon Resilience Plan for responding to the consequences of naturally occurring seismic events associated with geologic shift along the Cascadia subduction zone. The Task Force's report is due to the legislature by October 1, 2014.	X	X	X				X		4				X			X					2	Oregon Resilience Plan	**2**	**18**	OEM			2017	
REVISED CI-4D	Use DAS-EAM compiled data and investigation/inventory of seismic and flood risk to DAS-owned and -leased buildings in effective, routine decision processes for building occupancy, maintenance, use and potential mitigation treatments.	This information over time can provide for strategic and responsible voluntary seismic upgrade in areas of greatest need for reasonable cost as a part of broader facilities management.	X	X							2				X	X							2	Oregon Resilience Plan, NFIP	**2**	**17**	DAS-CFO			2017	
NEW CI-23	Identify, prioritize, and map areas susceptible to rapid channel migration	Identify areas susceptible to rapid channel migration. Prioritize those areas' susceptibility and rank their risk from a rapid channel migration event. Create channel migration zone and risk maps for the areas determined to have the highest risk for rapid channel migration.	X	X	X				X	X	5					X							1	NFIP, Risk MAP, Statewide Planning Goal 7	**2**	**17**	DOGAMI	DLCD		2016	
NEW EO-71	Prepare model coordination protocols for local Floodplain Managers and Building Officials.	Local government Floodplain Managers and Building Officials are often unaware of the other's role in floodplain management and how they could work together to better manage floodplain development and mitigate flood hazards. Providing model protocols for the two positions to coordinate would increase each one's awareness of the other's role, ultimately enhancing local flood hazard mitigation.	X	X						X	3					X							1	NFIP, ORS 455	**2**	**17**	DLCD			2016	

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85	**NEW CI-24**	Identify funding to support various transportation providers and local jurisdictions to conduct comprehensive vulnerability assessments of their transportation facilities and services.	OSSPAC, in the Oregon Resilience Plan has identified an immediate near-term need to inventory and assess vulnerability and mitigation opportunities for local street networks, transit assets, ports, airports, and railroads.	X	X	X						3				X			X					2	Oregon Highway Plan (OHP); The Oregon Resilience Plan	**2**	**16**	OEM, DOGAMI, ODOT			2016	
96	**LP-16**	Develop incentives to increase the rate of replacement of privately-owned seismically deficient buildings	Develop tax incentives, permitting facilitation, other means to increase the natural rate of building turnover.	X	X	X						3				X								1	Portland City Council	**2**	**14**	OEM			2017	
48a	**NEW MP-33**	Identify areas on the coast that will be "islands", or cut off, from other cities or critical recovery resources following a Cascadia Subduction Zone earthquake & tsunami.	Produce GIS database of resources in each "island" expected to be isolated after a Cascadia Subduction Zone earthquake and resulting tsunami in order to preplan for response. Shapefiles are to be imported into RAPTOR, Oregon Explorer, and other GIS tools.	X	X	X						3				X			X					2	Oregon Resilience Plan	**3**	**23**	OEM	DOGAMI		2018	
91	**NEW CI-25**	Prioritize mitigation and retrofit projects on seismic lifelines.	ODOT Seismic Lifelines Evaluation, Vulnerability Synthesis and Identification Report provides recommended priority corridors but does not provide sufficient detail to actually prioritize retrofit investment packages. Engineering evaluations and cost estimation are ongoing on a funding-available basis and will inform that prioritization process.	X	X							2				X								1	Oregon Highway Plan (OHP); The Oregon Resilience Plan	**3**	**22**	ODOT			2018	
47	**Revised MP-5**	Complete implementation of NFIP Map Modernization program in Oregon.	Work cooperatively with FEMA to ensure that the NFIP map modernization program is fully implemented in Oregon, giving high priority to remapping of coastal areas due to age of existing FIRM maps and potential severity of flooding and related erosion hazards.	X	X					X	X	4					X							1	Risk MAP	**3**	**22**	DLCD, DOGAMI			2018	
48d	**NEW MP-36**	Evaluate sediment impacts to Oregon's water resources.	Oregon has unique water resources, some of which are for drinking water. Landslides can have a great impact on this resource by input of large amounts of sediment. Evaluation of erosion potential by watershed would help the regulators and providers identify areas for mitigation.	X		X		X				3						X						1		**3**	**22**	DOGAMI	DEQ		2018	
31a	**REVISED LU-8B**	Provide funding and technical assistance to local governments to use the new guidance on classifying lands subject to natural hazards in their buildable lands inventories and adjusting urban growth boundaries to protect life, property, and the environment from natural hazards while providing for efficient development patterns.	Local governments need funding and technical assistance to be able to use the new guidance on how to classify lands subject to natural hazards and adjust urban growth boundaries to protect life, property, and the environment from natural hazards while providing for efficient development patterns within urban growth boundaries. Comprehensive Plan amendments are likely to result. This funding and technical assistance will promote integration of local natural hazard mitigation plans with comprehensive plans.	X	X		X				X	4	X	X	X	X	X	X	X	X	X	X	X	11	Statewide Planning Goals	**3**	**21**	DLCD			2018	
30	**LU-5**	Develop guidance on determination of mudslides/mudflow triggers and relation to rain/flood events	Work with FEMA Region 10, DOGAMI, and other interested parties to develop scientifically and legally-based guidance on when mudflows/mudslides are to be considered part of a rain/flood event pursuant to the NFIP. Address the definition of mudflow/mudslide, regulatory factors, scientific understanding of mudslides, and implications for flood insurance.	X	X							2					X							1	NFIP	**3**	**20**	DLCD, DOGAMI			2018	
23	**NEW EO-64**	Update the 2000 Guidelines for conducting site-specific geohazard investigations.	The state has guidelines for conducting site-specific seismic investigations. The guidelines date from 2000 and need to be updated. The update should expand the scope of the guidelines to cover site-specific investigations for all geohazards.	X	X						X	3	X			X		X		X				4	Statewide Planning Goal 7	**3**	**19**	DOGAMI			2018	
80	**NEW MP-32**	Implement sea level rise modeling		X	X	X				X	X	5	X											1	Oregon Climate Change Adaptation Framework	**3**	**19**	DOGAMI	DLCD		2018	
44	**EO-15**	Coordinate development of a post-disaster scientific and technical clearinghouse with other state and federal agencies, higher education, and associations.	When an earthquake, flood, tsunami, or other disaster strikes the state, there will be an influx of scientists and engineers from inside and outside the state to study the event and offer help. There needs to be a coordination of their efforts to put them to use in the most efficient and effective way possible. This clearinghouse will work with the emergency coordination center established immediately after the earthquake, flood, tsunami, or other disaster.	X	X			X		X		4	X	X	X	X	X	X	X	X	X	X	X	11	Silver Jackets	**3**	**18**	OEM	DLCD, DOGAMI		2018	

1	OREGON NHMP MISSION: TO CREATE A DISASTER RESILIENT STATE OF OREGON.
2	OREGON NHMP VISION: NATURAL HAZARD EVENTS RESULT IN NO LOSS OF LIFE, MINIMAL PROPERTY DAMAGE AND LIMITED LONG-TERM IMPACTS TO THE ECONOMY.

3	Action Item			Goal									Hazard												Integrated	Level of Support	Score	Implementation				
4	2012 #	Statement	Description	1 - Protect Life	2 - Protect Property	3 - Inc Ec Resilience	4 - Protect Env	5 - Enh OR Capability	6 - Evaluate Progress	7 - Info & Ed	8 - Elim Haz Area Dev	# Goals	Coastal Hazards	Drought	Dust Storms	Earthquakes	Floods	Landslides	Tsunamis	Volcanic Hazards	Wildfires	Windstorms	Winter Storms	# Hazards	Other Initiative	1 = Likely by 3/2018 2 = Not sure 3 = Unlikely by 3/2018	Score ≈ Benefit/Cost	Lead	Support	Potential Funding Source(s)	Target Completion Date	Status
88	**REVISED MP-28**	Update Special Paper 29	Update 1999 Special Paper 29, Earthquake Damage In Oregon: Preliminary Estimates of Future Earthquake Losses, a statewide damage and loss estimation study. This update, at a minimum, should incorporate damage and loss estimates for a magnitude 9 Cascadia earthquake, an exposure analysis of tsunami hazards, and probabilistic hazards including updated probabilistic earthquake ground motions and flooding zones. School and emergency facilities from the 2007 DOGAMI database should be incorporated.	X	X							2				X	X		X					3	Oregon Resilience Plan	**3**	**18**	DOGAMI			2018	
86	**Revised MP-14**	Develop probabalistic multi-hazard risk maps for the Oregon Coast	Consider and examine combinations and permutations of multi-hazard risk exposure and maps for the entire Oregon Coast.	X	X	X				X	X	5	X			X	X	X	X		X	X	X	8	Oregon Resilience Plan, NFIP, Risk MAP,	**3**	**17**	DOGAMI			2018	
78a	**REVISED CI-7B**	LIDAR survey the State's ROW (rights of way), west of the Cascade Range, to determine where seismic fault potential exists.	The acquired information can improve critical infrastructure (CI) resilience in the face of seismic events, by providing useful information to planners, design professionals and decision makers prior to delivery system construction.	X	X	X		X		X	X	6				X								1	Oregon Resilience Plan	**3**	**17**	DOGAMI	ODOT		2018	
87	**MP-23**	Assess hazards associated with active crustal faults newly discovered by statewide lidar program.	Particularly in central and eastern Oregon, the major earthquake hazards result from poorly known crustal faults. Lidar has greatly expanded the ability to find these faults, which should be systematically evaluated for their potential to generate damaging earthquakes using trenching, geophysical and field studies	X	X							2				X								1	Oregon Resilience Plan	**3**	**15**	DOGAMI			2018	

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5	**Revised CI-1A**	Complete statewide hazard identification: • Earthquakes • Tsunamis • Volcanoes • Flooding • Landslides • Coastal Hazards • Wildfire • Drought • Dust Storms • Wind Storms • Winter Storms	Complete hazard identification and characterization, including in terms of probabilities: • Coastal Hazards: Identify the coastal hazards, including rate and amount of movement, in terms of probabilities. • Drought: Identify the drought hazards statewide, including in terms of probabilities. • Dust Storms: Identify the dust storm hazards statewide, including in terms of probabilities. • Earthquakes: Identify statewide liquefaction susceptibility, lateral spreading susceptibility, co-seismic landslide susceptibility, soft soils and basins that amplify ground shaking, and active faults. • Flooding: Identify the flooding hazards statewide, in terms of probabilities. • Landslides: Identify the landslide hazards statewide, including rate and amount of movement, in terms of probabilities. • Volcano: Identify the volcanic hazards statewide, including in terms of probabilities. • Windstorms: Identify the wind storm hazards statewide, including in terms of probabilities. • Winter Storms: Identify the winter storm hazards statewide, including in terms of probabilities.	X	X	X				X	X	5	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Resilience Plan; Statewide Planning Goal 7; NFIP; Risk MAP; Oregon Climate Change Adaptation Framework	**1**	**29**	IHMT Agencies			2015	
82	**Revised CI-1L**	Complete statewide risk assessment: • Earthquakes • Tsunamis • Volcanoes • Flooding • Landslides • Coastal Hazards • Wildfire • Drought • Dust Storms • Wind Storms • Winter Storms	Assess the exposure, their vulnerabilities and estimate damage and losses. Exposure could include schools, emergency facilities, water and waste water, dams and levees, transportation, telecommunications and the energy sector.	X	X	X				X	X	5	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Resilience Plan, NFIP, Risk MAP, Oregon Climate Change Adaptation Framework	**1**	**29**	IHMT Agencies			2015	
90	**Revised CI-1M**	Complete statewide risk prioritization: • Earthquakes • Tsunamis • Volcanoes • Flooding • Landslides • Coastal Hazards • Wildfire • Drought • Dust Storms • Wind Storms • Winter Storms	Identify and then prioritize the highest risk issues for each hazard.	X	X	X				X	X	5	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Resilience Plan, NFIP, Risk MAP, Oregon Climate Change Adaptation Framework	**1**	**29**	DOGAMI, ODF, OWRD, OEM, ODOT			2015	
94	**Revised CI-1N**	Complete statewide resilience initiatives: • Earthquakes • Tsunamis • Volcanoes • Flooding • Landslides • Coastal Hazards • Wildfire • Drought • Dust Storms • Wind Storms • Winter Storms	Implement measures to improve the reliability of critical services	X	X	X			X		X	5	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Resilience Plan, NFIP, Risk MAP, Oregon Climate Change Adaptation Framework	**1**	**29**	IHMT Agencies			2018	
12	**Revised EO-9**	Develop and fund a legislative package for general funds or lottery funds to match federal funding for local hazard mitigation planning, including additional funds for DLCD Technical Assistance Grants.	Continue – and enhance where possible – state technical and planning grant assistance to cities and counties for addressing issues associated with local hazards.	X	X	X	X	X		X	X	7	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Local Disaster Assistance Loan and Grant Account. This account addresses the need for local match for federal funding of projects, but not planning	**1**	**28**	DLCD			2015	

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61	**NEW MP-10A**	Create a "Clearinghouse" for natural hazards data	Emergency responders and community planners alike need to know where to find the best and most current natural hazards data that is available. This project: - Establishes a single point of online access to reliable data and information about natural hazards; - Develops, in conjunction with DAS GEO, a "portal" to distribute this data; - Provides an ongoing inventory and assessment of existing natural hazards data; and - Creates a central library for natural hazard risk assessments.	X	X			X		X	X	5	X	X	X	X	X	X	X	X	X	X	X	11	Risk MAP; RiskPlan; Framework Implementation Teams; OEM's Master Dataset; LHMPs; Governor's interagency collaboration initiative; Goal 7 implementation; NFIP; DEQ's IRIS database; etc.	**1**	**23**	DLCD	DAS, DEQ, DOGAMI		2016	
7	**LP-2***	Complete a hazard mitigation policy legislative needs assessment	The Oregon NHMP contains a number of specific policy recommendations. In addition, the state of Oregon maintains a number of policies related to natural hazards and the mitigation thereof. It is unclear at this time what legislative action may be needed in order to fully implement existing and proposed mitigation actions. The State IHMT has identified greater interaction with the legislature as a top priority in the coming years. As a first step, the State IHMT recommends completing an assessment of the potential legislation needed to implement hazard mitigation policies. The assessment shall review existing and proposed policies and develop a list of potential legislative priorities.	X	X	X	X	X	X	X	X	8	X	X	X	X	X	X	X	X	X	X	X	11		**1**	**22**	OEM			2015	
31	**REVISED LU-8A**	Develop guidance for local governments on how to use Goal 7 together with other pertinent Statewide Land Use Planning Goals to classify lands subject to natural hazards in the buildable lands inventory and adjust urban growth boundaries in a manner that minimizes or eliminates potential damage to life, property, and the environment while continuing to provide for efficient development patterns.	Goal 7 discourages new development in areas subject to natural hazards. Goal 14 and other Statewide Land Use Planning Goals encourage development within urban growth boundaries. Local governments need guidance on how to classify lands subject to natural hazards in their buildable lands inventories and adjust urban growth boundaries to protect life, property, and the environment from natural hazards while providing for efficient development patterns within urban growth boundaries. This guidance will assist local governments in integrating local natural hazard mitigation plans with comprehensive plans.	X	X	X	X				X	5	X	X	X	X	X	X	X	X	X	X	X	11	Statewide Planning Goals	**1**	**21**	DLCD			2018	
48b	**NEW MP-34**	Identify communities along the Oregon coast that should consider vertical evacuation structures and improved evacuation routes due to evacuation constraints.	Use the anisotropic path modeling to measure the time needed to evacuate all parts of the maximum-considered Cascadia tsunami inundation zone in order to evaluate the need for vertical evacuation structures and improvements in evacuation routes.	X		X				X		3	X			X			X					3	Oregon Resilience Plan	**1**	**21**	DOGAMI			2015	
33a	**NEW LU-20**	Provide guidance to the maritime community for evacuation response for local Cascadia and distant tsunami events.	Tsunami model data including minimum flow depths and maximum flow velocities, will be analyzed to determine port-specific maritime guidance.	X						X		2	X			X			X					3	Oregon Resilience Plan	**1**	**21**	OEM, DOGAMI	DLCD		2015	
106	**NEW MP-37**	Develop new standardized risk assessment methodology across all hazards, at the state and local levels.	Oregon does not have a clear and common methodology to identify the most vulnerable populations across all hazards at the state and local levels. In 2013, the IHMT RAS-C in partnership with the OPDR and the InfoGraphics Lab at the University of Oregon developed a model concept, 3-year workplan and budget. Pending funding, this model could be fully developed between 2014-2017 and then be used to inform the 2018 OR NHMP. Upon full development, the model will allow state and local governments to better identify where to strategically target mitigation resources.	X	X							2	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Resilience Plan, NFIP, Risk MAP, Oregon Climate Change Adaptation Framework, Oregon Health Authority	**1**	**20**	DLCD	DEQ, OEM, DOGAMI, UO, Business Oregon, FEMA		2017	
108	**NEW CI-~~26~~27**	Complete a Climate Change Vulnerability Assessment and Adaptation Pilot for north coast highways.	The goal of ODOT's pilot is to conduct a regional vulnerability assessment and prepare options for adaptation actions and priorities. In coordination with ODOT Maintenance, the project will collect and map vulnerability and risk data based on climate science, asset conditions, and known and anticipated natural hazards. Hazard sites will be selected within a study corridor for more detailed analysis. Based on engineering and technical reviews, adaptation measures will be developed for vulnerable infrastructure and assembled into a coastal adaptation implementation plan. ODOT received a Federal Highway Administration grant to conduct the project, scheduled for completion in fall 2014.	X	X							2	X			X	X	X	X					5	Oregon Resilience Plan, NFIP, Risk MAP, Oregon Climate Change Adaptation Framework, Oregon Health Authority	**1**	**20**	ODOT			2015	

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11	**NEW LP-24**	Request LCDC to include Local Natural Hazard Mitigation Planning as a priority for DLCD Technical Assistance Grant awards to use as match for federal funds when available.	The Land Conservation and Development Commission (LCDC) awards Technical Assistance Grants to local governments to support local planning efforts in certain priority land use topic areas which at this time do not include natural hazard mitigation. If LCDC were to include natural hazard mitigation planning as a priority topic area, local governments would have the opportunity to compete for funding and the state would be better able to provide technical assistance for natural hazard mitigation planning.	X	X	X	X	X		X	X	7	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Local Disaster Assistance Loan and Grant Account. This account addresses the need for local match for federal funding of projects, but not planning	**1**	**19**	DLCD			2015	
28	**LU-2***	Develop a process for implementing revised elements of Goal 7	Goal 7 currently includes a process for notification to local governments of new hazard information. It also requires that local governments review any new hazard information brought to their attention and determine if a local land use response is needed. (LCDC adopted the revised goal in 2001. The revised Goal 7 became effective in June 2002.) Since the Goal's revision, several studies and reports on natural hazards have been published and disseminated. The process for determining which information should trigger local land use evaluations, however, remains untested.DLCD will implement the process, review the results, and determine whether any changes are necessary. This action is necessary to ensure that local governments evaluate and respond to information regarding natural hazards within their communities.	X	X						X	3	X	X	X	X	X	X	X	X	X	X	X	11	Statewide Planning Goal 7	**1**	**19**	DLCD	DOGAMI		2015	
102	**REVISED CI-14A**	Develop plans for rapid mobilization of inspectors for post disaster facility inspection.	Create rapid communication networks to effectively alert necessary inspectors when disasters occur. Work with OEM, local government building officials, and emergency planners to establish an effective process for assigning inspection teams to needed areas and educating local governments regarding the circumstances and process for initiating BCD and state involvement.			X		X				2	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Resilience Plan	**1**	**19**	BCD, OEM			2015	
9	**REVISED LP-12**	Work with Business Oregon to introduce in 2015 legislation allowing reconstruction of structures that cannot feasibly be retrofitted.	Revise SRGP legislation or develop an alternate funding mechanism to help replace schools and emergency facilities that are too structurally deficient for cost-effective retrofit and need to be replaced instead. This would also include structures in the "local" tsunami inundation zone that should not be retrofit in-place but, rather, rebuilt on natural high ground.	X	X	X						3				X			X					2	Oregon Resilience Plan	**1**	**19**	OEM			2015	
25	**CI-19**	Develop evacuation plans for ports and harbors	Ports and harbors are the haven for commercial and recreational fishing and recreational boating industries. They are often the major centers of economic activity in coastal communities that have bays. To protect the vessels from tsunami damage requires a unique evacuation plan for both distant and local tsunamis. The plans should be integrated with community evacuation plans. The Oregon State University Extension Sea Grant Program has identified this as a major issue in their pilot project in Yaquina Bay. Their project is titled *Reducing Earthquake and Tsunami Hazards in the Pacific Northwest Ports and Harbors.* For distant tsunami events and storm surge events that can occur during any winter, evaluate potential port and harbor mitigation retrofit projects that protect and strengthen floating and anchored infrastructure such as piers, bulkheads and landings.	X	X	X						3	X			X			X					3	Oregon Resilience Plan, OSU Extension Sea Grant Program	**1**	**18**	OEM, DOGAMI	DLCD		2015	
33	**REVISED LU-17A**	Integrate the GIS database of tsunami safe zones and assembly areas into local government databases.	Assist counties not only with how to integrate the data, but also how the data can be used for tsunami evacuation planning.	X						X		2	X						X					2	Oregon Resilience Plan	**1**	**18**	OEM	DOGAMI		2015	
19	**REVISED LP-10**	Incorporate text addressing hazard mitigation into natural resource agencies' guidance and process documents focusing on environmental quality to ensure that natural resources are protected in the design and construction of hazard mitigation projects.	Government and private nonprofit agencies in Oregon must address complex issues associated with flood hazard mitigation in the context of clean drinking water, riparian habitat, watershed health, fisheries, wetlands protection, and overall environmental quality. An important plan related to this effort is the *Oregon Plan for Salmon and Watersheds.* Solutions require multi-agency and intergovernmental efforts. While the decisions and projects will vary with each disaster, the state will continue its efforts to develop appropriate policies and criteria to ensure that these are considered along with hazard mitigation needs. This includes guidance on large wood placement, restoration after flood events, and habitat-friendly methods to accomplish pre- and post-disaster hazard mitigation. Watershed assessments being completed around the state by local watershed councils will be used in the evaluation of flood hazards and floodplain processes.				X					1	X				X							2	Oregon Plan for Salmon & Watersheds	**1**	**18**	ODFW, DSL			2015	

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29	**REVISED LU-3***	Provide technical assistance to local governments to help integrate hazard mitigation plans with local comprehensive plans.	Local NHMPs are often adopted as an appendix to the comprehensive plan or separately and are therefore in practice not used to their full potential. By assisting local governments in integrating the two plans, hazard mitigation will be more easily and meaningfully implemented in local land use planning practice. In late 2013, a pilot project to integrate the CIty of Madras's comprehensive plan and NHMP began, and is expected to be completed within a year. It is anticipated that more local jurisdictions will undertake this effort when updating their NHMPs or comprehensive plans.	X	X	X	X			X	X	6	X	X	X	X	X	X	X	X	X	X	X	11	Statewide Planning Goal 7	**1**	**17**	DLCD, OPDR			2015	
84a	**REVISED CI-4A***	Request and compile seismic and flood information for personnel-occupied buildings from other agencies and the university system.	Determine earthquake damage and losses expected to occur to the state owned building inventory including higher education buildings. Produce information to enable development of statewide priorities and strategies to guide mitigation of earthquake risk, to protect lives during an earthquake, and to preserve ongoing operations after an earthquake. Use accepted methods to determine building type, construction and occupancy, to estimate damage and losses due to various earthquake scenarios and probabilities relating to building codes.	X	X							2				X	X							2	Oregon Resilience Plan, NFIP	**1**	**17**	DAS-EAM	DOGAMI		2015	
84b	**REVISED CI-4B***	Request seismic and flood information from landlords as part of analyzing potential leased spaces going forward in new leases and potential renewals.	Determine earthquake damage and losses expected to occur to the state owned building inventory including higher education buildings. Produce information to enable development of statewide priorities and strategies to guide mitigation of earthquake risk, to protect lives during an earthquake, and to preserve ongoing operations after an earthquake. Use accepted methods to determine building type, construction and occupancy, to estimate damage and losses due to various earthquake scenarios and probabilities relating to building codes.	X	X							2				X	X							2	Oregon Resilience Plan, NFIP	**1**	**17**	DAS-EAM	DOGAMI		2015	
26	**NEW CI-22**	Fund and provide technical assistance for local governments to engage in evacuation route planning and project implementation.	After a Cascadia Subduction Zone earthquake, a tsunami could arrive within minutes. It is essential that residents and visitors be able to quickly move to high ground. Some evacuation planning is already underway. Local governments need funding and technical assistance to begin or continue to engage in evacuation planning.	X								1	X			X			X					3	OSSPAC, Statewide Planning Goal 7, ORS 455	**1**	**15**	OEM, DLCD, DOGAMI			2016	
103	**REVISED CI-21**	Implement better wayfinding solutions for tsunami evacuation. Create hardened and improved evacuation routes to include elevated safe areas above the level of modeled inundation.	After a Cascadia Subduction Zone earthquake, a tsunami could arrive within minutes. It is essential that residents and visitors be able to quickly move to high ground on foot. This requires clearly marked and safe routes that pedestrians are able to navigate even in dark and stormy weather. Where high ground is available, projects should be identified that will enable Oregon to establish new standards and guidelines for methods to harden and mark way-finding of tsunami evacuation routes to natural high ground. Where natural high ground is not within the expected evacuation time, evaluate the retrofit of existing facilities and/or construction of new facilities that rise above the level of tsunami inundation and can serve as safe haven refuges.	X						X		2	X			X			X					3	Oregon Resilience Plan	**1**	**14**	OEM, DOGAMI			2015	
10	**NEW LP-23**	Request the legislature to fund the "State Disaster Relief Fund" immediately following a presidentially declared disaster or other disaster.	The State Disaster Relief Fund includes an account that can be used to fund local government and school district mitigation projects after a presidentially declared disaster. The legislature may authorize deposits to the account when requested.	X	X	X						3	X	X	X	X	X	X	X	X	X	X	X	11		**1**	**11**	OEM			2015	
6	**LP-1***	Review and re-establish State IHMT membership and member responsibilities	When first established, the State IHMT membership consisted largely of agency directors or other high level agency staff. Over time, agency interaction with and oversight of State IHMT activities has been delegated. In some instances, this has resulted in better connection with the individuals that are actually responsible for mitigation activities in the respective agencies. In other cases, such delegation has resulted in the loss of an overall understanding of mitigation activities occurring throughout individual agencies. Given the lack of dedicated resources at the agency level for participation in the State IHMT, a review and re-establishment of the State IHMT membership and member responsibilities based on current resource constraints is needed.	X	X	X	X	X	X	X	X	8	X	X	X	X	X	X	X	X	X	X	X	11	OSSPAC, OWEB	**2**	**23**	OEM			2017	
8	**LP-3***	Establish statutory authority for the State IHMT	Since its formation, the State IHMT has continued to play major roles in hazard mitigation activities, including the development of this hazard mitigation plan. There is strong agreement that the State IHMT is important, should be continued, and ought to be made permanent because it is the only state body focused on coordination of natural hazard mitigation. It is recommended that the State IHMT be formally established in Oregon statute.	X	X	X	X	X	X	X	X	8	X	X	X	X	X	X	X	X	X	X	X	11	OSSPAC	**2**	**23**	OEM			2017	
92	**NEW LU-19**	Develop a system for prioritizing and ranking state-owned critical facilities for mitigation.		X	X	X						3	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Resilience Plan	**2**	**23**	DOGAMI, DLCD, OEM	DAS-EAM		2016	

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22	**EO-11**	Produce Coastal Development Handbook	Produce a *Coastal Development Handbook* that addresses coastal process and hazards, beach and shoreland public policy, buying oceanfront property [what to look for, what questions to ask], building on oceanfront property, choosing appropriate hazard mitigation techniques, and choosing and using geotechnical consultants and engineers.	X	X	X	X	X		X	X	7	X			X	X	X	X					5	Statewide Planning Goals 5 & 7	**2**	**22**	DLCD	DOGAMI		2017	
107	**NEW MP-38**	Develop new climate-hazard data and a social vulnerability index; and integrate into local NHMPs.	There is high demand among various agencies for 1) fine-grained data on social vulnerability and 2) climate-induced hazard data. Furthermore, local decision makers lack tools to understand the drivers of vulnerability and the magnitude of disaster risk associated with climate change. OHA, DLCD, DOGAMI and UO have collaborated to create a NOAA grant proposal to develop 2 new data sets for Oregon: 1) a social vulnerability index for the entire State and 2) climate-induced flood data for one watershed. Both data sets will be at the census tract scale. The new data will be applied in one pilot watershed to inform a LNHMP update. This project will also further the development of the new risk assessment model that will inform the State and local communities more strategically target mitigation resources.	X	X							2	X	X	X	X	X	X	X	X	X	X	X	11	Oregon Resilience Plan, NFIP, Risk MAP, Oregon Climate Change Adaptation Framework, Oregon Health Authority	**2**	**21**	OHA	DLCD, DOGAMI, UO		2017	
21	**Revised EO-6A**	Update *Planning for Natural Hazards: Oregon Technical Resource Guide.*	*Planning for Natural Hazards: Oregon Technical Resource Guide* was published in 2000 and needs to be updated.	X	X	X	X	X		X	X	7	X	X	X	X	X	X	X	X	X	X	X	11	Statewide Planning Goal 7	**2**	**20**	DLCD, OPDR			2017	
104	**NEW CI-26**	Continue to act upon opportunities to advance the State's lifeline mitigation investment practice. - - **ONGOING?**	Expand upon the State's mitigation investment practice by: (1) Supporting efforts by jurisdictions and transportation districts to develop mitigation policy and retrofit plans for lifeline assets and service facilities; (2) Continuing to advance design and maintenance standards and requirements for bridges and unstable slopes, transit, rail, ports, and priority lifeline airfields; (3) Developing a temporary bridge installation policy and standards; (4) Supporting research on retrofit methods and strategies for Cascadia subduction zone earthquake loads and tsunamis.	X	X	X						3	X			X	X	X	X					5	Oregon Highway Plan (OHP); The Oregon Resilience Plan	**2**	**20**	OEM, ODOT			2017	
62a	**NEW EO-72**	Facilitate self sustaining outreach programs staffed by Community Emergency Response Teams (CERT) or CERT-like organizations in each coastal population center aimed at creating a culture of preparedness and response for both local Cascadia and distant tsunami events.	Nearly all coastal communities participated at some level over the last 4 years in implemention of outreach techniques tested in a 2005 pilot study of Seaside (#1 priority = door-to-door education; #2 priority = community evacuation drill; #3 = K-12 education supplemented by workshops targeted at specific user groups such as the lodging industry). Sustainability of these pilot programs needs to be measured, deficits identified and resolved (State facilitation and leadership needed).	X		X				X		3	X			X			X					3	Oregon Resilience Plan	**2**	**20**	OEM	DOGAMI		2016	
105	**NEW MP-31**	Support and implement the actions in the February 2013 Oregon Resilience Plan and recommended in the Oregon Resilience Plan Task Force's October 2014 report (SB33, 2013).	The Oregon Resilience Task Force was established by Senate Bill 33. It is tasked to facilitate a comprehensive and robust plan to implement the strategic vision and roadmap of the Oregon Resilience Plan for responding to the consequences of naturally occurring seismic events associated with geologic shift along the Cascadia subduction zone. The Task Force's report is due to the legislature by October 1, 2014.	X	X	X				X		4				X			X					2	Oregon Resilience Plan	**2**	**18**	OEM			2017	
84c	**REVISED CI-4D**	Use DAS-EAM compiled data and investigation/inventory of seismic and flood risk to DAS-owned and -leased buildings in effective, routine decision processes for building occupancy, maintenance, use and potential mitigation treatments.	This information over time can provide for strategic and responsible voluntary seismic upgrade in areas of greatest need for reasonable cost as a part of broader facilities management.	X	X							2				X	X							2	Oregon Resilience Plan, NFIP	**2**	**17**	DAS-CFO			2017	
85	**NEW CI-24**	Identify funding to support various transportation providers and local jurisdictions to conduct comprehensive vulnerability assessments of their transportation facilities and services.	OSSPAC, in the Oregon Resilience Plan has identified an immediate near-term need to inventory and assess vulnerability and mitigation opportunities for local street networks, transit assets, ports, airports, and railroads.	X	X	X						3				X			X					2	Oregon Highway Plan (OHP); The Oregon Resilience Plan	**2**	**16**	OEM, DOGAMI, ODOT			2016	
48a	**NEW MP-33**	Identify areas on the coast that will be "islands", or cut off, from other cities or critical recovery resources following a Cascadia Subduction Zone earthquake & tsunami.	Produce GIS database of resources in each "island" expected to be isolated after a Cascadia Subduction Zone earthquake and resulting tsunami in order to preplan for response. Shapefiles are to be imported into RAPTOR, Oregon Explorer, and other GIS tools.	X	X	X						3				X			X					2	Oregon Resilience Plan	**3**	**23**	OEM	DOGAMI		2018	
31a	**REVISED LU-8B**	Provide funding and technical assistance to local governments to use the new guidance on classifying lands subject to natural hazards in their buildable lands inventories and adjusting urban growth boundaries to protect life, property, and the environment from natural hazards while providing for efficient development patterns.	Local governments need funding and technical assistance to be able to use the new guidance on how to classify lands subject to natural hazards and adjust urban growth boundaries to protect life, property, and the environment from natural hazards while providing for efficient development patterns within urban growth boundaries. Comprehensive Plan amendments are likely to result. This funding and technical assistance will promote integration of local natural hazard mitigation plans with comprehensive plans.	X	X		X				X	4	X	X	X	X	X	X	X	X	X	X	X	11	Statewide Planning Goals	**3**	**21**	DLCD			2018	
23	**NEW EO-64**	Update the 2000 Guidelines for conducting site-specific geohazard investigations.	The state has guidelines for conducting site-specific seismic investigations. The guidelines date from 2000 and need to be updated. The update should expand the scope of the guidelines to cover site-specific investigations for all geohazards.	X	X						X	3	X			X		X		X				4	Statewide Planning Goal 7	**3**	**19**	DOGAMI			2018	

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44	**EO-15**	Coordinate development of a post-disaster scientific and technical clearinghouse with other state and federal agencies, higher education, and associations.	When an earthquake, flood, tsunami, or other disaster strikes the state, there will be an influx of scientists and engineers from inside and outside the state to study the event and offer help. There needs to be a coordination of their efforts to put them to use in the most efficient and effective way possible. This clearinghouse will work with the emergency coordination center established immediately after the earthquake, flood, tsunami, or other disaster.	X	X			X		X		4	X	X	X	X	X	X	X	X	X	X	X	11	Silver Jackets	**3**	**18**	OEM	DLCD, DOGAMI		2018	
88	**REVISED MP-28**	Update Special Paper 29	Update 1999 Special Paper 29, Earthquake Damage In Oregon: Preliminary Estimates of Future Earthquake Losses, a statewide damage and loss estimation study. This update, at a minimum, should incorporate damage and loss estimates for a magnitude 9 Cascadia earthquake, an exposure analysis of tsunami hazards, and probabilistic hazards including updated probabilistic earthquake ground motions and flooding zones. School and emergency facilities from the 2007 DOGAMI database should be incorporated.	X	X							2				X	X		X					3	Oregon Resilience Plan	**3**	**18**	DOGAMI			2018	
86	**Revised MP-14**	Develop probabalistic multi-hazard risk maps for the Oregon Coast	Consider and examine combinations and permutations of multi-hazard risk exposure and maps for the entire Oregon Coast.	X	X	X				X	X	5	X			X	X	X	X		X	X	X	8	Oregon Resilience Plan, NFIP, Risk MAP, Oregon Climate Change Adaptation Framework	**3**	**17**	DOGAMI			2018	

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83	**NEW EO-66**	Refine coastal erosion risk mapping for Tillamook County and its cities to utilize a fully probabilistic approach.	Revise coastal erosion risk mapping and analysis for Tillamook County, and cities within the County, to utilize a fully probabilistic approach. Probablistic modeling approaches will be used to better address uncertainty and allow local and state hazard managers to use the information to better manage uses based on the relative risks. This will assist DLCD/DOGAMI to increase assistance to local governments in developing inventories based on sound technological research and in incorporating this information into their coastal management programs.	X	X					X	X	4	X											1	Statewide Planning Goal 7	**1**	**20**	DOGAMI	DLCD		2015	
45	**NEW EO-65**	Update the inventory of shoreline protective structures.	Update the inventory of existing and new coastal engineering (shore protection) structures on the Oregon Coast.	X	X							2	X											1		**1**	**19**	DLCD			2015	
50	**Revised EO-10**	Facilitate accessibility and use of the *Coastal Atlas* GIS resources. **- - ONGOING?**	Make the *Coastal Atlas* geographic information system (GIS) more useful for a wider audience, from local and state staff to interested citizens, by continuing to improve its data and tools, and providing training on how to access and use them.	X	X		X			X	X	5	X											1	Statewide Planning Goal 7	**1**	**18**	DLCD, OPRD			2016	
80	**NEW MP-32**	Implement sea level rise modeling		X	X	X				X	X	5	X											1	Oregon Climate Change Adaptation Framework	**3**	**19**	DOGAMI	DLCD		2018	

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35	**REVISED EO-13**	Determine the effectiveness of the Emergency Alert System (EAS) in dust prone areas at providing timeline information to the traveling public about dangerous blowing dust conditions and make improvements if needed.	One of several ideas proposed following the Sept. 1999 accidents on Interstate 84 near Echo was to "put word out quickly" utilizing the Emergency Alert System (EAS) via area radio stations about dust storm potential, and especially about actual conditions that are interfering with visibility. This idea was in addition to ODOT's Highway Advisory Radio and related resources noted as success stories on pages DS-5 to DS-7. With regard to the Mid-Columbia Region, it was noted that Tri-Cities radio stations need to be included because many people driving through that area are listening to stations based in Washington State. ODOT and OSP have primary responsibility for activating the traffic advisory components of the dust storm response plan for the Mid-Columbia Region. The National Weather Service can also activate EAS from their forecast offices in Pendleton, Boise, Medford, and Portland. Many local emergency program managers can also activate the system.	X							1		X								1		**2**	**20**	OEM	ODOT, OSP		2017	

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83	**EO-22**	Encourage the purchase of earthquake insurance - - **ONGOING?**	Unlike flood insurance, which is underwritten by the U.S. Government (through the National Flood Insurance Program), earthquake insurance is offered by private sector agents and generally "packaged" as a rider to a standard homeowner or business property insurance policy. For some people, the question should not be whether or not to purchase earthquake insurance, but rather, how much to buy. For others, the decision requires a risk assessment: how likely is an earthquake?; how much damage would it inflict on ones property?; and how much can one afford to lose? Earthquake insurance rates are determined differently by each insurance company and can vary widely depending on several rating factors. Generally, older homes cost more to insure than new homes. Wood homes get better rates than brick ones because they tend to withstand earthquake stresses better. Because earthquake insurance is a type of catastrophic coverage, most policies carry a high deductible; usually anywhere from 5% to 15% of the value of a house. It is recommended that state agencies, local governments, and private sector insurance companies do a better job of promoting the purchase of earthquake insurance.		X	X						2				X							1	Oregon Resilience Plan	**1**	**18**	DCBS-ID			2015	
45	**REVISED CI-4C***	Investigate/inventory DAS-owned buildings for seismic risk.	Determine earthquake damage and losses expected to occur to the state owned building inventory including higher education buildings. Produce information to enable development of statewide priorities and strategies to guide mitigation of earthquake risk, to protect lives during an earthquake, and to preserve ongoing operations after an earthquake. Use accepted methods to determine building type, construction and occupancy, to estimate damage and losses due to various earthquake scenarios and probabilities relating to building codes.	X	X							2				X							1	Oregon Resilience Plan	**1**	**17**	DAS-EAM	DOGAMI		2016	
50	**NEW EO-20B**	Achieve 100% state agency participation in the Great Oregon ShakeOut	Practicing to "Drop, cover, and hold" is critical in reducing injury and loss of life in the workplace and home during an earthquake. The more people practice the drill, the better they will respond to a real event. State agencies are setting an example by conducting a drill annually. The State of Oregon will have 100% State agency participation in the Great Oregon ShakeOut and will encourageschools and universities to participate.	X	X					X		3				X							1	Oregon Resilience Plan	**1**	**16**	OEM			2018	
80	**LP-15**	Develop incentive/subsidy program for retrofit of one and two family residences	Design a system of grants or tax credits to encourage homeowners to retrofit residences to minimize displaced post-earthquake shelter demand and reduce population loss during recovery.	X	X	X						3				X							1	Clean Energy Works; Portland City Council; Certified local contractors	**1**	**14**	OEM			2018	
35	**LP-16**	Develop incentives to increase the rate of replacement of privately-owned seismically deficient buildings	Develop tax incentives, permitting facilitation, other means to increase the natural rate of building turnover.	X	X	X						3				X							1	Portland City Council	**2**	**14**	OEM			2017	
58	**NEW CI-25**	Prioritize mitigation and retrofit projects on seismic lifelines.	ODOT Seismic Lifelines Evaluation, Vulnerability Synthesis and Identification Report provides recommended priority corridors but does not provide sufficient detail to actually prioritize retrofit investment packages. Engineering evaluations and cost estimation are ongoing on a funding-available basis and will inform that prioritization process.	X	X							2				X							1	Oregon Highway Plan (OHP); The Oregon Resilience Plan	**3**	**22**	ODOT			2018	
84	**REVISED CI-7B**	LIDAR survey the State's ROW (rights of way), west of the Cascade Range, to determine where seismic fault potential exists.	The acquired information can improve critical infrastructure (CI) resilience in the face of seismic events, by providing useful information to planners, design professionals and decision makers prior to delivery system construction.	X	X	X		X		X	X	6				X							1	Oregon Resilience Plan	**3**	**17**	DOGAMI	ODOT		2018	

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57	**MP-23**	Assess hazards associated with active crustal faults newly discovered by statewide lidar program.	Particularly in central and eastern Oregon, the major earthquake hazards result from poorly known crustal faults. Lidar has greatly expanded the ability to find these faults, which should be systematically evaluated for their potential to generate damaging earthquakes using trenching, geophysical and field studies	X	X							2				X								1	Oregon Resilience Plan	**3**	**15**	DOGAMI			2018	

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48	**NEW MP-5B**	Through FEMA's Risk MAP program, update 1,000 miles of streams with lidar-based flood mapping	FEMA's Risk MAP program funds revisions for Flood Insurance Studies and Flood Insurance Rate Maps. The State should focus on updating these products so they are based on high quality topographic data (e.g. lidar). The State should continue to pursue Risk MAP funds primarily for this purpose.	X	X					X	X	4					X							1	NFIP	**1**	**22**	DLCD, DOGAMI			2016	
38	**NEW MP-15A**	Implement the Rapid Assessment of Flooding Tool	The RAFT (Rapid Assessment of Flooding Tool) has been funded by the US Army Corps of Engineers (USACE) through FY 14 for $115,000. The goal of the RAFT is to take real time flood forecasts and relate them to flood frequency curves from FEMA, USGS, and OWRD. This will help decision makers prioritize real-time flood fighting assistance. The tool will also incorporate other important decision-influencing factors, possibly including structures in danger of flooding, population affected, and likelihood of levee failure. The RAFT is intended to work in concert with and feed data to other tools, such as the RAPTOR. The tool is in very early development, and the scope and schedule are under development. For the remainder of the year, the RAFT team will focus on developing the scope and schedule, identifying data needs, and tasking members to track down data. The development of the RAFT will pick up more steam in FY 14, when more labor resources are available from the Corps. Once RAFT is developed, OEM will have operational oversight when the ECC is activated.	X	X							2					X							1	Silver Jackets	**1**	**22**	DLCD	OEM, DOGAMI, OWRD		2016	
77	**NEW EO-37C**	Produce new lidar-based flood hazard maps **- - ONGOING?**	Through FEMA or otherwise.	X	X	X				X	X	5					X							1	NFIP, Risk MAP	**1**	**21**	DOGAMI	DLCD		2018	

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60	**NEW EO-68**	Create an informational website for the new Base Flood Elevation Determination Service.	Create website that describes the state's base Flood Elevation Determination Service. Website will include brochure, pricing, map of completed determinations, and data clearinghouse for completed determinations.	X	X					X	X	4					X							1	NFIP, Risk MAP	**1**	**21**	DOGAMI	DLCD		2015	
98	**REVISED EO-1*A**	Add at least one jurisdiction, with emphasis on coastal jurisdictions, to the Community Rating System (CRS) program during the life of each Oregon NHMP.	The CRS, part of the NFIP, is a program that rewards communities for going above and beyond the minimum requirements of the NFIP in minimizing potential losses due to flooding. Participating in the CRS benefits the jurisdiction with extra flood protection and benefits property owners by lowering flood insurance rates. The state will continue its efforts to implement CRS in local communities. See the CRS Information Center at: http://training.fema.gov/EMIWeb/CRS/ for more information. Each year DLCD conducts community assistance visits in an average of five NFIP communities. During this process, qualified jurisdictions will be encouraged to participate in CRS or strengthen CRS ratings. DLCD will also create a "pathway to CRS" schedule for each jurisdiction for which it conducts a community assistance visit.	X	X	X				X		4					X							1	NFIP	**1**	**19**	DLCD			2018	

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43	**NEW LP-22**	Update the state's Peak Discharge Estimation Program.	Peak discharge estimation tools can help determine the magnitude and frequency of floods. The state's program provides engineers and land managers with the information needed to make informed decisions about development in or near watercourses. The Peak Discharge Estimation Program is based on a modified version of the U.S. Geological Survey's "Bulletin 17b." The U.S. Geological Survey is in the process of updating this bulletin. OWRD's methodology will need to be brought up to date to reflect these recent findings.	X	X							2					X								1	Integrated Water Resource Strategy	**1**	**19**	OWRD			2016	
97	**REVISED LP-19A**	Develop and implement flood protection standards for state-owned and -leased buildings.	According to the Senate Bill 814 Task Force (Oregon Legislature, 1997 Session), there is a need to develop and effectively implement a strict standard governing the siting, construction, and leasing of buildings occupied by state agencies in flood-prone areas.	X	X							2					X							1	NFIP	**1**	**19**	DAS	DLCD		2015	
99	**NEW EO-1B**	Strengthen the existing CRS rating of at least one jurisdiction, with emphasis on coastal jurisdictions, during the life of each Oregon NHMP.	The CRS, part of the NFIP, is a program that rewards communities for going above and beyond the minimum requirements of the NFIP in minimizing potential losses due to flooding. Participating in the CRS benefits the jurisdiction with extra flood protection and benefits property owners by lowering flood insurance rates. There are a number of measures a community can implement to obtain a CRS rating, and most communities do not implement them all. As a community implements more CRS flood protection measures, its CRS rating is strengthened, and the community is rewarded with better flood protection and lower flood insurance rates.	X	X	X				X		4					X							1	NFIP	**1**	**18**	DLCD			2018	

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101	**NEW EO-69**	Establish a web page where building owners can register their interest in participating in acquisition programs for flood-damaged buildings. The on-line page complements OEM and DLCD's on-going prospective outreach to owners of identified Repetitive Loss and Severe Repetitive Loss buildings.	FEMA funds can be used to buyout repetitive loss and severe repetitive loss properties in the floodplain. The paperwork and process to achieve a buyout are lengthy and complex. First and foremost, a property owner must be willing to sell. Buyout funds could be more efficiently and effectively spent if willing sellers were identified and paperwork prepared before funds became available. This registry would augment the state's current outreach efforts, making it easy for willing sellers to identify themselves and for the state to prepare for and execute buyouts.	X	X	X				X		4					X							1	NFIP	**1**	**18**	DLCD, OEM			2015	
42	**NEW LP-21**	Install real-time monitoring capabilities on state-operated stream gages **- - #/yr? all the rest by 20__?**	The availability of timely and accurate data from stream gages is essential for flood forecasting, for prediction of imminent flood hazards, and for response to flood emergencies. Today, 178 of the state's 229 stream gages provide real-time data. Upgrade the state's existing stream gaging network, with the goal of installing real-time capability on all remaining gages.	X	X							2					X							1	Integrated Water Resource Strategy; Silver Jackets	**1**	**15**	OWRD	ODF		2016	
62	**NEW MP-10B**	Develop a multi-agency State of Oregon flood hazard website	Create one-stop data, information, and map clearinghouse for flood hazards. Website will be cooperative effort between authoritative data sources -- DLCD, DOGAMI, OEM, OWRD, and federal partners (FEMA, USACE, NWS, USGS).	X	X	X				X	X	5					X							1	NFIP, Risk MAP	**2**	**21**	DLCD, DOGAMI	OWRD		2016	

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39	**NEW MP-15B**	Add at least three new flood inundation forecast points to the National Weather Service's Flood Inundation Mapping website and the USGS's Flood Inundation Mapper before 2018.	The National Weather Service Advanced Hydrologic Prediction Service (AHPS) has developed inundation mapping sites for various stream gage locations nationwide. Currently Oregon does not have any sites with inundation mapping. This is a useful emergency management tool for understanding potential inundation areas based on NWS forecasts. (National Weather Service: http://water.weather.gov/ahps/inundation.php; U.S. Geological Survey: http://wim.usgs.gov/fimi/)	X	X							2					X							1	National Weather Service, Silver Jackets	**2**	**19**	DOGAMI	OWRD		2017	
79	**NEW CI-23**	Identify, prioritize, and map areas susceptible to rapid channel migration	Identify areas susceptible to rapid channel migration. Prioritize those areas' susceptibility and rank their risk from a rapid channel migration event. Create channel migration zone and risk maps for the areas determined to have the highest risk for rapid channel migration.	X	X	X				X	X	5					X							1	NFIP, Risk MAP, Statewide Planning Goal 7	**2**	**17**	DOGAMI	DLCD		2016	
24	**NEW EO-71**	Prepare model coordination protocols for local Floodplain Managers and Building Officials.	Local government Floodplain Managers and Building Officials are often unaware of the other's role in floodplain management and how they could work together to better manage floodplain development and mitigate flood hazards. Providing model protocols for the two positions to coordinate would increase each one's awareness of the other's role, ultimately enhancing local flood hazard mitigation.	X	X						X	3					X							1	NFIP, ORS 455	**2**	**17**	DLCD			2016	
47	**Revised MP-5**	Complete implementation of NFIP Map Modernization program in Oregon.	Work cooperatively with FEMA to ensure that the NFIP map modernization program is fully implemented in Oregon, giving high priority to remapping of coastal areas due to age of existing FIRM maps and potential severity of flooding and related erosion hazards.	X	X					X	X	4					X							1	Risk MAP	**3**	**22**	DLCD, DOGAMI			2018	

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30	**LU-5**	Develop guidance on determination of mudslides/mudflow triggers and relation to rain/flood events	Work with FEMA Region 10, DOGAMI, and other interested parties to develop scientifically and legally-based guidance on when mudflows/mudslides are to be considered part of a rain/flood event pursuant to the NFIP. Address the definition of mudflow/mudslide, regulatory factors, scientific understanding of mudslides, and implications for flood insurance.	X	X							2					X							1	NFIP	**3**	**20**	DLCD, DOGAMI			2018	

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33b	**NEW EO-73**	Form an Oregon Landslide Workgroup.	An Oregon Landslide Workgroup will be created to prioritize areas for new mapping projects, to promote landslide hazard awareness through education & outreach, to develop and influence policy at the federal state, and local levels, and to assist in response & recovery efforts during disasters.	X	X	X		X		X		5						X						1		**1**	**22**	DOGAMI			2015	
40a	**NEW EO-74**	Upgrade the Oregon Landslide Warning System.	The current warning system needs updating to include rainfall thresholds from local rainfall gauges. A permanent real-time website will be constructed to show the areas under a landslide warning that will include guidance on what people should do to help protect their life and property from a landslide.	X	X			X		X		4						X						1		**1**	**22**	DOGAMI			2015	
27	**LU-1***	Develop model risk reduction techniques and ordinances for landslide-prone communities	Techniques can involve requiring geological or geotechnical studies for new development, storm water control for neighborhoods on hillslopes, strict land use ordinances for active landslides, working with infrastructure operators to increase reliability of services after storms, and more.	X	X						X	3						X						1	Statewide Planning Goal 7	**1**	**22**	DLCD	DOGAMI		2015	
78	**REVISED CI-7A**	LIDAR survey the State's ROW (rights of way), west of the Cascade Range, to determine where landslide potential exists.	The acquired information can improve critical infrastructure (CI) resilience in the face of landslide events, by providing useful information to planners, design professionals and decision makers prior to delivery system construction.	X	X	X				X	X	5						X						1	Statewide Planning Goal 7	**1**	**17**	DOGAMI	ODOT		2015	
48c	**NEW MP-35**	Evaluate the impact of climate change on landslides.	The precipitation-triggered landslides will increase or decrease with changes in climate. Evaluation of this change will be important for the future of Oregon.	X	X						X	3						X						1	Oregon Climate Change Adaptation Framework	**2**	**22**	DOGAMI			2016	
75	**EO-37**	Create new LiDAR-based Landslide Inventory and Susceptibility Maps, especially near population centers. - - **ONGOING?**	DOGAMI will create these maps in cooperation with local municipalities. Specific methods and priority locations are still to be determined.	X	X	X				X	X	5						X						1	Statewide Planning Goal 7	**2**	**21**	DOGAMI			2018	

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48d	**NEW MP-36**	Evaluate sediment impacts to Oregon's water resources.	Oregon has unique water resources, some of which are for drinking water. Landslides can have a great impact on this resource by input of large amounts of sediment. Evaluation of erosion potential by watershed would help the regulators and providers identify areas for mitigation.	X		X		X				3						X						1		**3**	**22**	DOGAMI	DEQ		2018	

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100	**REVISED EO-39A**	Enroll 3 coastal communities in the Tsunami Ready Program each year.	The Tsunami Ready Program is a program sponsored by the National Weather Service that is designed to provide communities with incentives to reduce their tsunami risk. Cannon Beach was the first community for Oregon. Under a proposed plan through the National Tsunami Hazard Mitigation Program (NTHMP), three communities per year will be added to the rolls of the program. This program is currently evolving through a review process being carried out by the NTHMP National Coordinating Committee. OEM is the primary point of contact for more information about the Tsunami Ready Program.	X	X	X				X		4							X					1	Oregon Resilience Plan	**1**	**23**	OEM	DOGAMI		2018	

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55	**NEW EO-19B**	Host at least one workshop or other educational opportunity on a biennial basis in communities where a Volcano Coordination Plan has been adopted. **- - ONGOING?**	The State of Oregon will actively work to increase the public's knowledge of the volcano hazard in Oregon.	X	X					X	X	4								X				1		**1**	**16**	OEM			2018	

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Action Item					**Progress**
2012 #	Statement	Description	**Lead(s)**	**Support(s)**	Comments
LEGISLATIVE/ POLICY					
NEW LP-5C	Assist local governments in implementing the land use guidance and best practices for reducing risk within tsunami inundation zones.	The risk of tsunami hazard for Oregon's coastal communities is well-documented with the completion of comprehensive tsunami inundation maps developed by DOGAMI. The State of Oregon can assist affected communities by developing land use guidance for tsunami risk reduction, providing it to the communities, then assisting communities with its implementation. Monitoring success of the guidance will allow the State to adjust its approach and update the guidance as necessary.	DLCD		**ONGOING - Start Date 2015**
NEW LP-5D	Monitor the effectiveness of the land use guidance and best practices for reducing risk within tsunami inumdation zones provided to local governments by tracking the number of jurisdictions that have used it.	The risk of tsunami hazard for Oregon's coastal communities is well-documented with the completion of comprehensive tsunami inundation maps developed by DOGAMI. The State of Oregon can assist affected communities by developing land use guidance for tsunami risk reduction, providing it to the communities, then assisting communities with its implementation. Monitoring success of the guidance will allow the State to adjust its approach and update the guidance as necessary.	DLCD		**ONGOING - Start Date 2015**
REVISED LP-13A	Seek stable funding for the installation, operation, and maintenance of additional stream gages.	The availability of timely and accurate telemetered data from stream gages is essential for flood forecasting, for prediction of imminent flood hazards, and for response to flood emergencies. Stream gaging data also provide basic hydrologic information for floodplain mapping and watershed management by communities throughout the state. Numerous agencies of the federal government need data from stream gages for effective management of projects and resources; therefore the installation and maintenance of stream gages has traditionally been a responsibility of the government. State agencies plan to work with their federal counterparts to ensure adequate funding and support for existing gages and for the installation of new gaging sites where required. It is recommended that state agencies endeavor to leverage federal funding with state resources and local matching commitments to achieve a reliable network of stream gages around the state.	OWRD		**ONGOING -** The 2013 Oregon Legislature provided $750,000 for two hydrologic technicians, one information services position, and 16 stream gages.OWRD will always seek to install more gages throughout the state, and operation and maintenance are inherently ongoing activities.

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Action Item					Progress
2012 #	Statement	Description	Lead(s)	Support(s)	Comments
REVISED LP-17	Collaborate through work groups within the Pacific Northwest Coordination Group to encourage the U.S. Forest Service to allow the owners of long-term dwelling leases to apply mitigation standards adjacent to their dwellings.	In Oregon, several thousand seasonal homes, which are located in high-risk wildland-urban interface areas, are on lands owned by the U.S. Forest Service. Because these structures are located on ground owned by the federal government, they are not subject to the *Oregon Forestland-Urban Interface Fire Protection Act* . In many locations, even when the owners of these homes desire to complete wildfire mitigation practices, federal lease requirements totally or substantially prevent them from doing so. Under this action item, a survey will be made of all lease locations in Oregon and the federal mitigation limitation and prohibitions will be identified. This information will then be used to approach the appropriate federal officials with a request to change their policies or regulations, to allow for the application of mitigation practices on leased property.	ODF	OSFM	**ONGOING**
REVISED LP-19B	Continue to improve inventory of state-owned and -leased buildings in all hazard areas,	Using DAS's data, DOGAMI developed an inventory of state-owned and -leased buildings and identified those in hazard areas for the 2012 Plan and updated the inventory for the 2015 Plan. The data should be continuously updated by DAS to facilitate DOGAMI's inventory updates in future plan cycles.	DAS	DOGAMI	**ONGOING**
EDUCATION/ OUTREACH					
NEW EO-63	Monitor the effectiveness of the statewide strategy to encourage the purchase of flood insurance by demonstrating that the number of flood insurance policies held throughout the state continues to increase.	Despite the statewide availability of flood insurance, coverage in place in most communities in Oregon varies from 10% to 20% of the homes and businesses located in the Special Flood Hazard Area (100-year floodplain). Not only does flood insurance reduce the financial vulnerability of individuals, families, businesses, government agencies, other organizations, and the community to the costs posed by flooding, but through the "increased cost of compliance" provision of flood insurance, it also provides funding for the elevation, floodproofing, demolition, or relocation of homes and businesses when required due to "substantial damage" to the structure.	DLCD	DCBS-ID	**ONGOING - Start Date 2015**
NEW EO-6B	Provide the updated *Planning for Natural Hazards: Oregon Technical Resource Guide* to local governments.	To encourage communities to use *Planning for Natural Hazards: Oregon Technical Resource Guide* it must be provided to them.	OPDR	DLCD, OEM	**ONGOING - Not started**
NEW EO-6C	Assist local governments in using the updated *Planning for Natural Hazards: Oregon Technical Resource Guide* to update their comprehensive plans and development regulations.	The original purpose of *Planning for Natural Hazards: Oregon Technical Resource Guide* was to assist communities in amending their comprehensive plans and development regulations to reduce risk from natural hazards, implementing Statewide Goal 7. The updated document will also be helpful in developing local hazard mitigation plans and integrating them with local comprehensive plans and development regulations.	OPDR	DLCD, OEM	**ONGOING - Not started**
NEW EO-6D	Monitor the success of the updated *Planning for Natural Hazards: Oregon Technical Resource Guide* provided to local governments by evaluating its effectiveness or uptake rate.	Monitoring success of *Planning for Natural Hazards: Oregon Technical Resource Guide* will allow the State to adjust its approach and update the guidance as necessary.	OPDR	DLCD, OEM	**ONGOING- Not started**
NEW EO-6E	Provide support for development of local and state hazard mitigation plans.	The State provides support for development of local NHMPs and the state NHMP by managing federal grant funding that it distributes to OPDR and others to assist the state and local governments with NHMP development and update tasks and processes.			**ONGOING**

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Action Item					Progress
2012 #	Statement	Description	Lead(s)	Support(s)	Comments
EO-7	Improve and sustain public information and education programs aimed at mitigating the damage caused by natural hazards	While ongoing efforts are being made in this area, a strong message conveyed by several State IHMT Reports notes the need to strengthen and sustain public information, education, and training efforts by providing additional resources. Although commonly recognized that interest in reducing losses increase during and after events, there is an ongoing need to provide residents and key stakeholder groups (such as infrastructure operators) with hazard mitigation information. These reports cite the need to have timely seasonal information available, better methods to inform residents of sources of hazard mitigation information, use improved electronic methods (e.g., web sites), and materials oriented toward the intended users. This helps keep awareness levels higher, will stimulate actions by some, and reminds users to consider and include hazard mitigation measures in the contexts of regular activities, such as building a new home, relocating an office, or repairing a business.	OEM	State IHMT Agencies	**ONGOING**
EO-12	Better coordinate, fund, and publicize programs to reduce the abundance of Juniper trees in arid landscapes across Oregon	Juniper trees develop extensive root systems that draw critically needed water from arid soils, transpiring water vapor into the atmosphere, intensifying drought and increasing the risk of wildfire. There are programs in Oregon to reduce Juniper trees from areas where their competition for groundwater resources is harmful, but these programs need to be better coordinated, funded, and publicized.	ODF	ODA, DEQ, ODFW, DSL	**ONGOING**
REVISED EO-17	Publicize and facilitate the implementation of both structural and non-structural seismic mitigation measures for home owners, business owners, renters, and contractors, including methods of reducing hazards	Working with federal partners, such as FEMA, and non-profit industry groups, such as AIA, Oregon will enhance education on structural and non-structural seismic mitigation measures by adopting the following actions: • Increase the number of educational opportunities by working with FEMA to offer courses from the National Earthquake Technical Assistance Program. • Work with the Construction Contractors Board, public and private sector lenders, private sector construction material suppliers and nonprofit organizations to develop programs to assist home and business owners and renters to implement innovative structural and non-structural seismic mitigation measures.	OEM	BCD	**ONGOING**
REVISED EO-19A	Designate May to be Volcano Awareness Month by Governor's declaration.	Working with federal partners, such as the USGS Cascades Volcano Observatory, the state of Oregon will increase the ability for citizens to respond to volcanic eruptions by increasing the level of awareness and preparedness in the public and governmental agencies.	OEM		**ONGOING - Annually**
REVISED EO-20A	Designate the third Thursday of the month of October as the Great Oregon ShakeOut Day by declaration of the Governor.	Practicing to "Drop, cover, and hold" is critical in reducing injury and loss of life in the workplace and home during an earthquake. The more people practice the drill, the better they will respond to a real event. A gubernatorial declaration will promote increased participation in the Great Oregon ShakeOut, or other annual earthquake Drop, Cover, and Hold On drill.	OEM		**ONGOING - Annually**
NEW EO-75	Designate a month to be Earthquake and Tsunami Awareness Month by Governor's declaration.	Practicing to "Drop, cover, and hold" is critical in reducing injury and loss of life in the workplace and home during an earthquake. The more people practice the drill, the better they will respond to a real event. A gubernatorial declaration will promote increased participation in the Great Oregon ShakeOut, or other annual earthquake Drop, Cover, and Hold On drill.	OEM		**ONGOING - Annually**

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Action Item					Progress
2012 #	Statement	Description	Lead(s)	Support(s)	Comments
EO-27	Support development, enhancement and implementation of local education programs designed to mitigate the wildfire hazard and to reduce wildfire losses, such as the Firewise Communities/NFPA Progarm and the annual Wildfire Awareness Week Campaign.	As part of its statewide fire prevention program, the Oregon Department of Forestry actively encourages and promotes local education and awareness programs that are designed to mitigate, or reduce the impacts of wildfires. This action reflects ODF's ongoing intentions to: 1) collaborate with agencies and organizations to promote consistency in the development and application of fire prevention standards; 2) work to make individuals aware of their personal accountability and responsibility for wildfire safety; 3) determine local resources and capacity; and 4) define needs and solutions required to increase capacity.	ODF	OSFM, BCD, DCBS-ID, DLCD	**ONGOING - Annually**
EO-28	Increase the number of local governments using the Wildfire Hazard Zone process to mitigate wildfire risk and losses	The Wildfire Hazard Zone (WHZ) process allows local governments to require the use of fire resistant roofing materials in jurisdictions assessed to be at a high risk of wildland fire. Currently, only a few eligible entities have utilized the WHZ process. To promote additional use, an assessment will be made of the portions of the state where it appears the WHZ process will have the greatest benefit. Following this assessment, local governments in the areas identified will be educated on the desirability of implementing the process. Those governments that express an interest in applying the process will be assisted in completing the required analysis work.	ODF, BCD	OSFM	**ONGOING - Through 2015**
EO-29	Increase the number of counties and communities that have current Community Wildfire Protection Plans.	The federal Healthy Forests Restoration Act (HFRA) includes statutory incentives for federal agencies to give consideration to the priorities of local communities as they develop and implement wildfire hazard mitigation projects. To become eligible for priority consideration under HFRA, a community must first prepare a *Community Wildfire Protection Plan* (CWPP). Most Oregon counties and many Oregon communities have completed CWPPs. To encourage the completion of additional CWPPs, as well as future updates of CWPP's counties and communities will be informed of the benefits to be gained from maintaining a CWPP and assistance will be offered to help facilitate the development and/or update of the plans.	ODF	OSFM	**ONGOING - Through 2015**
EO-33	Promote the use of monies for fire prevention and wildfire mitigation projects by counties received pursuant to Title III, Section 302(5) of Public Law 106-393, or other similar federal legislation	Under the federal *Secure Rural Schools and Community Self-Determination Act of 2000* , counties have the ability to receive and spend federal funds for projects that educate homeowners about wildfire mitigation efforts they can apply on their property and for planning projects that increase the protection of people and property from wildfires. Under this action item, counties will be encouraged to apply for these monies and guidance will be offered on how the monies can best be applied.	ODF	OSFM	**ONGOING - Dependent upon budget coordination**
EO-34	Promote "flood fight" plans and protocols	Several State IHMT Reports call for the development of flood fight plans and protocols in advance of flood emergencies. In addition to the state agencies potentially involved in flood fighting such as OEM, WRD, and the National Guard, environmental protection and habitat conservation agencies such as DEQ and ODFW should be involved in flood fight planning. At the federal level, the U.S. Army Corps of Engineers is a key partner. These plans and protocols might include improving emergency warnings, strengthening communications systems, stockpiling needed materials, preparing procedures for emergency vehicle access to flooded areas, and other related subjects, including ongoing public education efforts.	OEM	State IHMT agencies and OMD	**ONGOING**

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Action Item					Progress
2012 #	Statement	Description	Lead(s)	Support(s)	Comments
REVISED EO-35A	Continue the State's active Floodplain Management Outreach Program	DLCD has an active floodplain and natural hazards outreach program. The department publishes and distributes newsletters and other outreach information to local governments and other interested parties. DLCD also maintains a website which includes a link to this NHMP. The natural hazards website (http://www.oregon.gov/LCD/HAZ/index.shtml) contains information and links to floodplain management information including many of the documents and booklets prepared by FEMA. DLCD uses an email distribution service for its Natural Hazard Newsletter and other correspondence. The email distribution service affords interested subscribers a greater opportunity to obtain flood management and natural hazards information from DLCD in a timely manner and for DLCD to more readily share information from a variety of sources.	DLCD		**ONGOING**
REVISED EO-35B	Continue the State's active Floodplain Management Training Program	DLCD and other State IHMT participants also conduct or sponsor training sessions and meetings throughout the year focused on up-to-date floodplain management practices and projects. DLCD will continue to deliver focused training to surveyors, building officials, real estate agents and planners as well as local floodplain managers. The interdependent relationships among these key players in providing comprehensive floodplain management will also be highlighted during trainings.	DLCD		**ONGOING**
REVISED EO-35C	Prepare text for local broadcast of one Public Service Announcement (PSA) each year on a seasonal topic.	PSAs are an effective method for disseminating pertinent seasonal information about hazard preparedness and mitigation.	DLCD		**ONGOING**
NEW EO-39B	Continue to renew enrollment of coastal communities already enrolled in the Tsunami Ready Program.	The Tsunami Ready Program is a program sponsored by the National Weather Service that is designed to provide communities with incentives to reduce their tsunami risk. Cannon Beach was the first community for Oregon. Under a proposed plan through the NTHMP, three communities per year will be added to the rolls of the program. This program is currently evolving through a review process being carried out by the NTHMP National Coordinating Committee. OEM is the primary point of contact for more information about the Tsunami Ready Program.	OEM		**ONGOING**
NEW EO-40A	Increase the number of schools participating in annual tsunami evacuation drills.	Increase the ability of Oregonians to prepare for and recover from earthquakes and tsunamis on the Oregon Coast.	OEM, DOGAMI	DLCD, ODOT	**ONGOING - Not started**
NEW EO-40B	Increase the number of local agency and local non-profits, such as CERT, to participating in educational efforts such as door-to-door campaigns to educate those living or working in the inundation zone on how to response to an earthquake and tsunami.	Increase the ability of Oregonians to prepare for and recover from earthquakes and tsunamis on the Oregon Coast.	OEM, DOGAMI	DLCD, ODOT	**ONGOING - Not started**
NEW EO-40C	Increase the number of innovative outreach activities, such as tsunami evacuation route fun runs.	Increase the ability of Oregonians to prepare for and recover from earthquakes and tsunamis on the Oregon Coast.	OEM, DOGAMI	DLCD, ODOT	**ONGOING - Not started**
EO-43	Encourage local jurisdictions to disseminate volcano preparedness educational materials	Preparedness materials should include what to do in the event of an eruption, evacuation maps, and volcano specific items to include in first aid kits (e.g., breathing masks and goggles). The USGS and FEMA have existing educational materials.	OEM	DOGAMI	**ONGOING**
REVISED EO-46	Develop volcanic hazard evacuation maps	Volcanic eruptions often produce lahars that travel down river valleys. Evacuation maps should include the hazard area as well as preferred evacuation routes and evacuation sites. USGS staff should support local and state agencies in this effort.	OEM	ODOT, DOGAMI	**ONGOING**

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REVISED EO-48	Educate communities, workers, and the public about the role of proper tree pruning and care in preventing damage during windstorms	Arboricultural groups, public agencies, and utilities should cooperate in promoting proper tree pruning and care practices that can reduce the risk of tree failure and property damage. Common messages refined by state level entities such as the Oregon Department of Forestry (ODF) and OSU Extension can help provide continuity and efficiency across the state. While implementation of this action largely takes place at the local government level, the state has a role in encouraging and providing incentives for best management practices. ODF maintains and implements a communication plan that includes educational initiatives aimed at improving tree health in cities. This includes a variety of products, including a bimonthly newsletter, a website, and brochures that help convey these messages. OSHA requires utilities to: • Provide training to crews working on powerlines in worker safety and the identification of trees to prune or remove; and • Review regulations and standards for easement and right of way maintenance, and provide training to foresters and logging crews. Utilities should instruct homeowners in pruning of vegetation, tree care safety, and proper tree care for trees bordering utility corridors and public rights of way	ODF	PUC, OEM	**ONGOING**
REVISED EO-49	Educate motorists on safe winter driving, including how to be prepared for traveling over snowy and icy mountain passes.	Actions such as sanding, applying de-icing chemicals, and snowplowing do not make the road safe. Motorists must drive at speeds appropriate for the weather and road conditions, and be prepared to handle adverse conditions. During the December 2003 closure of the Siskiyou Pass on Interstate 5, ODOT and Oregon State Police freed many drivers only to have them spin out and get stuck again. If drivers would have had tire chains, and installed them when conditions warranted, clearing the pass would have been completed hours earlier. Many drivers were not prepared for a long wait in their car. Each year ODOT finds stranded motorists who either do not have or do not know how to install chains.	ODOT	OSP	**ONGOING**
EO-50	Encourage citizens to prepare and maintain 72-hour kits	State agencies should work with the American Red Cross and local emergency managers to encourage citizens to be prepared to survive on their own for 72 hours.	OEM	OERS agencies	**ONGOING**
EO-51	Educate citizens about the different National Weather Service announcements	State agencies should work with the National Weather Service and local governments to educate the public about the meaning of the different National Weather Service announcements: winter storm watch, winter storm warning, ice storm warning, heavy snow warning, blizzard warning, severe blizzard warning, dust storm and high wind warning.	OEM	ODOT, OSP	**ONGOING**

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EO-52	Educate citizens about safe emergency heating equipment	Improper use of alternate heat sources during winter storms can cause fires. Ongoing efforts of the Office of State Fire Marshal and it's work with local fire departments through the Life Safety Team (http://www.oregon.gov/OSP/SFM/CommEd_OLST.shtml) In addition, people can be killed by carbon monoxide emitted by fuels such as charcoal briquettes when used for heating homes. To reduce the threat of carbon monoxide poisoning, known as the silent killer, the 2009 Legislature passed HB3450a requiring landlords to install carbon monoxide alarms in rentals with a carbon monoxide source and homeowners must ensure they are installed in homes at the time of sale, if the home has a source. Sources include gas heating or fireplaces, woodburning fireplaces or stoves and attached garages. Partnerships for consistent public education messages and outreach are underway, and will include information on the dangers of introducing a carbon monoxide risk.	OSFM	OEM, OPH, BCD	**ONGOING**
REVISED EO-53	Educate citizens about ways to weatherize their homes	Weatherization measures can help keep the cold out during winter. Energy audits, cash rebates, and tax credits are available to help homeowners. Energy audits, cash rebates, and education are also provided by the Energy Trust of Oregon to customers of the regulated energy utiliites with oversight by the OPUC.	ODE	BCD, OPUC	**ONGOING**
EO-54	Educate citizens about the dangers of hypothermia, other winter health conditions	State agencies should work with the American Red Cross and local health authorities to educate citizens about the dangers of winter health conditions, including hypothermia, exhaustion, and heart attacks caused by overexertion.	OPH	OEM	**ONGOING**
EO-55	Educate homeowners about choosing ice and windstorm-resistant trees and landscaping practices to reduce tree-related hazards in future ice storms	Trees that don't stand up well to ice and wind, especially when planted near power lines, can cause power outages and other damage. Certain species of trees hold up better to winter's fury than others. Other factors, such as where a tree is planted and use of proper pruning techniques, can also help trees be more resistant to ice storm damage.	ODF	PUC, ODA	**ONGOING**
REVISED EO-58	Maintain the inventory of shoreline protection structures	Maintain the inventory of existing and new coastal engineering (shore protection) structures on the Oregon Coast.	DLCD	OPRD, DOGAMI	**ONGOING**
REVISED EO-60	Better understand beach processes by developing a coastal geomorphic database.	Develop a coastal geomorphic database that describes the various morphological parameters of beaches, dunes, and bluffs present along the central to northern Oregon coast, specifically in Clatsop and Tillamook Counties. As recent research has shown, ocean water levels and wave dynamics along the Oregon coast are changing. These will, in turn, affect beach sand budgets and rates of erosion. More research must be done on alternative shore protection methods, effects of hard shore protection structures, near-shore circulation processes and sediment budgets, sea cliff erosion processes, and other hazard processes. This effort is phase 1 of a needed future multi-phase effort.	DOGAMI, OSU	DLCD	**ONGOING**
REVISED EO-62A	Work with ODOT to replace or move existing Entering/Leaving Tsunami Hazard Zone signs to correspond with the XXL inundation line developed by DOGAMI.	Existing tsunami hazard zones signs are considered inadequate for placement along stretches of Highway 101, or on any roads, that are within the tsunami hazard zone. A single tsunami hazard zone sign will not indicate the boundaries of the inundation zone. Tsunami Hazard Zone signs should be located to correspond with the XXL inundation line developed by DOGAMI.	OEM		**ONGOING**

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NEW EO-62B	Work with ODOT to develop additional signage as needed to increase awareness of the tsunami hazard.	Existing tsunami hazard zones signs are considered inadequate for placement along stretches of Highway 101, or on any roads, that are within the tsunami hazard zone. A single tsunami hazard zone sign will not indicate the boundaries of the inundation zone. There is need for increased public education program to let the public, including motorists who are not local residents, know what the signs mean and what actions they should take.	OEM		**ONGOING**
NEW EO-62C	Work with Oregon Parks & Recreation Department and Oregon Travel Experience to increase the number of interpretive educational installations along Highway 101.	Existing tsunami hazard zones signs are considered inadequate for placement along stretches of Highway 101, or on any roads, that are within the tsunami hazard zone. There is need for increased public education program to let the public, including motorists who are not local residents, know what the signs mean and what actions they should take.	OEM		**ONGOING**
REVISED CI-2*	Continue to conduct and improve risk assessments for state owned properties	FEMA requires the state's plan to: 1) describe the types of state owned or operated critical facilities located in the identified hazard areas; and 2) present an estimate of the potential dollar losses to state owned or operated buildings, infrastructure, and critical facilities in the identified hazard areas. In addition, FEMA also requires that the state develop a comprehensive multi-year plan to mitigate the risks posed to existing buildings that have been identified as necessary for post-disaster response and recovery. Part of this risk assessment for state owned property should be to identify: 1) which facilities would be necessary for response and recovery efforts and 2) mitigation strategies for those priority facilities. Currently, the State Plan's assessment of state owned properties consists of a 'low,' 'moderate,' or 'high' vulnerability ranking. Rankings are derived from county-wide hazard analysis scores that do not account for local variations in vulnerability. Likewise, the structural integrity and physical condition of the critical facilities are not yet considered. As such, the State IHMT will encourage the state to invest resources in performing more detailed vulnerability assessments for state-owned properties. The assessments may result in mitigation opportunities that reduce the state's vulnerability to natural hazards.	DOGAMI, OPDR, DLCD	OEM	**ONGOING**
REVISED CI-3*	Provide information and technical assistance to implement mitigation of non-structural hazards in K-12 schools	Provide training to school officials and teachers in reducing non-structural hazards in schools such as unsecured bookcases, filing cabinets, and light fixtures, which can cause injuries and block exits. The program should include a procedure for periodic life safety inspections of non-structural seismic hazards in schools that can be implemented by local fire department inspectors. BCD will have an important role in providing technical assistance in the development of educational materials	OEM	OSSPAC, BCD, OSFM, ODE	**ONGOING**

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REVISED CI-5*	Strongly encourage voluntary relocation of existing essential facilities, hazardous facilities, and special occupancy structures that are in the tsunami inundation zone.	A large tsunami (preceded by a locally devastating earthquake) would likely destroy many buildings in coastal communities that are located in the tsunami inundation zone. The damage would be from the combined effects of the forces from the tsunami surges, currents and debris as well as the earthquake hazards. Essential facilities and special occupancy structures, such as fire stations/hospitals and schools, and hazardous facilities are often located in the tsunami inundation zone. Because of the critical need of essential facilities during a disaster, the added danger from hazardous materials, and the importance of protecting children, these facilities and structures need to be relocated out of the inundation zone through some type of incentive program. A voluntary program can be implemented without statutory change; however, a mandatory program would require legislative support. After a tsunami disaster, the top priority would be to reconstruct essential facilities, special occupancy structures, and hazardous facilities out of the tsunami inundation zone as defined in the maps produced for ORS 455.466 and 455.467. Finally, when these facilities come up for replacement, they should be encouraged to build out of the tsunami inundation zone.	OEM, DOGAMI, DLCD	BCD	**ONGOING**
REVISED CI-6	Continue seismic rehabilitation of hospital, fire, and police facilities under the Seismic Rehabilitation Grant Program administered by Business Oregon.	Continue to rehabilitate to operational readiness in the event of an earthquake essential hospital buildings, fire, and police stations that pose a threat to occupant safety. Senate Bill 15 of the 2001 Legislative Session requires that rehabilitation or other actions to be completed by January 1, 2022. SJR 21 and 22 are bond measures (November 2002 election) which would provide funding to implement this proposed action. Senate Bills 2 to 5 (2005) provided the mechanism to accomplish some of these legislatively mandated tasks. Under SB2, Oregon Department of Geology and Mineral Industries developed a seismic needs assessment database of emergency response facilities buildings. These data are being used the SRGP to administer a grant program which provides for seismic rehabilitation of eligible buildings (SB 3). Senate Bill 5 allows the State Treasury to sell Government Obligation Bonds to fund the program.	Business Oregon	OSSPAC, DOGAMI, BCD, OSFM (SB3). OEM, OHD	**ONGOING**
REVISED CI-8A	Improve reliability and resiliency of critical infrastructure by adopting industry-specific best practices, guidelines, and standards.	Lifeline Service Delivery Systems (aka: Critical Infrastructure(CI)), including electric supply, natural gas, telecommunications, water/wastewater, transportation corridors, pipelines and petroleum fuels' storage facilities, are all vital resources for a community's life-safety and economic viability. However, much of Oregon's existing critical infrastructure has not been designed or constructed to withstand the impact of severe natural disasters such as extreme wind & winter storms, major earthquakes, or large landslides. Lifeline Service Delivery Systems (CI) should have reliable and measurable performance objectives, which insure the region's CI can withstand future damage without crippling consequences.	DOGAMI	State IHMT Agencies	**ONGOING**
NEW CI-8B	Improve reliability and resiliency of critical infrastructure by adopting industry-specific best practices, guidelines, and standards.	OPUC insures National Electric Safety Code (NESC) and Commission Safety Rules (OAR: Chapter 860-Division 24) Compliance as it relates to Telecommunications Network and Electric Energy Utility Operators. OPUC Safety Staff provides Telecommunications and Electric Operators' workforce training related to the NESC and the Commission Safety Rules.	OPUC		**ONGOING**

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Action Item					**Progress**
2012 #	Statement	Description	**Lead(s)**	**Support(s)**	Comments
REVISED CI-9	Continue seismic rehabilitation of public schools buildings under the Seismic Rehabilitation Grant Program administered by Business Oregon.	Continue to rehabilitate to occupant life safety standards certain public school and community college buildings. Senate Bill 14 from the 2001 Session of the Oregon Legislature requires that the State Board of Education examine buildings used for both instructional and non-instructional activities, including libraries, auditoriums, and dining facilities in order to determine which buildings are in most need of additional analysis. Following the identification of high-risk buildings and additional analysis, high-risk buildings must be rehabilitated by January 1, 2032, subject to available funding. SJR 21 and 22 are bond measures (November 2002 election) which would provide funding to implement this proposed action. SB 2 to 5 (2005) provided the mechanism to accomplish some of these legislatively mandated tasks. Under SB2, Oregon Department of Geology and Mineral Industries developed a seismic needs assessment database of K-12 and Community College public school buildings. These data are being used the SRGP to administer a grant program for seismic rehabilitation of eligible buildings (SB 3). SB 4 allows the State Treasury to sell Government Obligation Bonds to fund the program.	Business Oregon	OSSPAC, DOGAMI, BCD, ODE (SB3)	**ONGOING**
REVISED CI-13	Evaluate the need and opportunities for inter-tie projects in Local Natural Hazard Mitigation Plans.	The capital expense associated with this action needs to be carried mostly by local governments, perhaps with some grant or low-interest loan funding provided by the state or federal governments. The role of the state in this action is to encourage local governments located proximate to one another, yet with separate water systems, to develop the physical capability to send water from one system to the other. Oftentimes during drought situations, one local government will have a bit of water to spare while a nearby government is struggling to meet its needs. Transferring water by truck is expensive and inefficient when compared to transferring water via pipeline. Water inter-ties are also effective mitigation for the flood and earthquake hazards where one system can serve as back-up for another.	Oregon Business	WRD	**ONGOING**
REVISED CI-14	Continue to maintain the existing roster of qualified post-earthquake, flood, and wind inspectors with ATC-20 earthquake and ATC-45 flood & wind inspection training.	Continue to compile and maintain a list of individuals trained and certified for post-disaster inspection. Support the recruitment and training of qualified ATC-20 post earthquake inspectors and inspection teams.	BCD	OEM, ODOT	**ONGOING**
REVISED CI-20	Use industry best practices to minimize impact and outages to service delivery system of overhead line operators, during windstorm events.	Implement outreach efforts through existing safety-related programs managed by the PUC in coordination with private and public utilities. Compliance with PUC administrative rules includes safety codes and vegetation management. The PUC provides administrative to support to the Oregon Utility Safety Committee where all utility operators (electric, natural gas, telecommunication & water) discuss safety issues and best practices.	PUC	ODF, ODOT, OR-OSHA	**ONGOING**

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Action Item					**Progress**
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REVISED LU-6	Implement the Oregon Forestland-Urban Interface Fire Protection Act ("Senate Bill 360") in all Oregon counties that meet criteria under the law.	The *Oregon Forestland-Urban Interface Fire Protection Act* , more commonly known as "Senate Bill 360," was enacted by the Oregon Legislature in response to the growing incidence of wildfire destroying homes and communities in Oregon's wildland-urban interface. The Act recognizes that individual property owners are in the best position to take mitigation actions which will have the most direct impact to whether or not a structure will survive a wildfire. Under this action item, the Act will be implemented county by county in those portions of the state, based on weather, fire incidence, fuels, or on the number of structures at risk. It has been Legislature's stated preference that implementation be accomplished with federal grant funds.	ODF	OSFM	**ONGOING - Through 2015**
REVISED LU-7	Update the Model Ordinance for Flood Damage Prevention	FEMA Region 10 has approved for use in Oregon a model ordinance for flood damage prevention. DLCD views the model ordinance as a living document and will continue to work with Region 10 and other interested parties to develop model ordinance provisions that address issues such as "fish-friendly" floodplain management, reducing flood insurance costs, etc.	DLCD	OEM, BCD	**ONGOING**
REVISED LU-12	Establish and maintain a priority ranking system for properties for flood mitigation	The State's strategy for selecting properties for flood hazard mitigation projects is four-fold. It prioritizes projects that 1) are geographically balanced 2) are in communities with a FEMA-approved local hazard mitigation plan, 3) address properties with sustained substantial damages or repetitive losses, 4) provide communities with information and/or tools to evaluate properties suitable for mitigation, and to develop mitigation projects. Repetitive flood loss properties (those which have experienced multiple flood insurance claims) have been identified as high priority hazard mitigation projects by the NFIP. The state, working with local jurisdictions, will verify the FEMA-provided repetitive flood loss information at least once during this plan's term and establish a priority ranking for properties that would benefit most from hazard mitigation by means of acquisition, relocation, elevation, or demolition. The state will maintain and review this list annually as a basis for selecting and funding hazard mitigation projects that directly benefit homeowners and businesses. The review of the repetitive lost list is tied to the FMA Program guidance that is updated annually with the state grant allocations. Following a major disaster declaration, these properties could be pre-approved by FEMA for hazard mitigation to include post-disaster mitigation funding from the Hazard Mitigation Grant Program that can oftentimes be	DLCD	OEM	**ONGOING**
LU-13	Maintain the Riparian Lands Tax Incentive Program	This program is administered by the ODFW. This program involves the preparation of a plan and agreement between the landowner and the ODFW. The plan details measures the landowner will implement to preserve, enhance, or restore the riparian areas. Landowners receive a complete property tax exemption for the riparian property (up to 100 feet from the top of stream bank or the edge of non-aquatic vegetation). This program helps reduce sediment and protect stream banks which helps reduce the filling of river and stream channels.	ODFW	ODR	**ONGOING**

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REVISED LU-15	Acquire existing homes and businesses seriously threatened or damaged by landslide hazards	When opportunities and funding become available (pre- and/or post-disaster) explore options for the acquisition of developed property, particularly homes, in areas of repetitive or ongoing landslide hazards. Acquired properties will be maintained as open space in perpetuity and may also provide a buffer for landslide movements and debris that could otherwise impact improvements such as transportation routes.	OEM	DOGAMI, ODF, DLCD	**ONGOING - and as opportunities (funding and project needs) arise**
REVISED LU-16	Continue to develop training and information packets and articles for local building officials informing them of their responsibilities and authority under ORS 455.446 and 455.447 and the State Building Code.	Statutes and the State Building Code limit construction of new essential facilities and special occupancy structures in the mapped tsunami inundation zone. Definitions of essential and special occupancy structures are in the Oregon State Structural Specialty Code. As personnel change and time passes, additional training and information for officials will be provided.	BCD, DLCD	DOGAMI, OEM	**ONGOING**
REVISED LU-18	Assist local communities in securing funding to mitigate damage to repetitive flood loss properties or those substantially damaged by flooding.	The state maintains an inventory of high priority repetitively damaged buildings located in floodplains (also see short-term action #7). As funding opportunities arise, continue to acquire, elevate, or otherwise mitigate damage to buildings exposed to or having experienced unacceptable flood damages. The flood event of December 2007 heavily impacted the City of Vernonia and the unincorporated Nehalem Valley. As a result of this flood, significant changes were made to flood hazard maps in the area, causing scores of buildings to be placed in the regulated flood hazard zone. DLCD and OEM have worked closely with these communities to secure funding to mitigate buildings now located in the flood hazard zone and to buyout properties now located in the floodway and will continue to provide such expertise statewide where needed.	OEM, DLCD	State IHMT agencies	**ONGOING**
NEW MP5A	Continue implementation of FEMA's RiskMAP program in Oregon, including building effective community strategies for reducing risk.	Measurably increase the public's awareness of flood and other natural hazards through a combination of regulatory and non-regulatory products, tools, community outreach. Address gaps in flood hazard data, identifying areas of dated and/or inconsistent mapping and updating high-priority areas with new mapping and innovative natural hazard mapping techniques that lead to actions that reduce risk to life and property. Provide support to help manage the FEMA Map Modernization projects that remain to be completed.			**ONGOING**
REVISED MP-9	Continue to assist local governments with GIS capability development	Assist local governments with GIS program development, including system planning, hardware/software costs, training, and data development in relation to all hazards mapping and regulation of coastal development.	DLCD, DAS-GEO	DOGAMI	**ONGOING**
MP-11	Survey coastline to monitor erosion	Continue to periodically measure and monitor the Oregon coastline in order to document the response of Oregon's beach and bluffs to changes in ocean water levels (sea level rise and storm surges), storms (frequency and intensity), precipitation patterns that may threaten lives and property. Maintain a long-term, permanent Oregon Beach and Shoreline Mapping and Analysis Program (OBSMAP). The program will be a partnership with local, state, and federal agencies that have responsibility over coastal and ocean activities.	DOGAMI	OSU, DLCD, OPRD	**ONGOING -** 30% of coast actively monitored; 60% monitored to a lesser degree.

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2012 #	Statement	Description	Lead(s)	Support(s)	Comments
REVISED MP-12	Analyze wildfire ignition probability statistics to better target prevention efforts at the leading causes of fires	There is currently no single database or common method of collecting fire cause information for wildfires occurring in Oregon. This results in different entities focusing their prevention and mitigation efforts on those causes which may not be the state's leading causes of fires. This likelihood can be lessened by developing a process to compare fire cause data collected by the Oregon Department of Forestry, the Office of State Marshal, and federal wildfire agencies. It is also important to understand the ignition probability from homes within and adjacent to the wildland interface because of the ignition risk to nearby wildlands. While there is no centralized database, wildland and structural fire agencies will continue to work collaboratively to determine leading fire causes and focus efforts statewide and locally to prevent future ignitions. We need to express this "collaboration" message in this item. "Keep Oregon Green," a atatewide non-profit fire prevention association could potentially play a significant role in the process.	ODF	OSFM	**ONGOING**
NEW MP-13A	Collaborate through work groups within the Pacific Northwest Coordination Group (PNWCG) to continue collecting and analyzing wildfire occurrence data using the standardized statewide method and report to the state legislature as required.		ODF		**ONGOING**
REVISED MP-20	Acquire statewide lidar coverage for the purpose of improving natural hazard mapping and infrastructure inventories.	Lidar is currently the best source of regional topographic data and allows for highly precise and accurate natural hazard mapping (landslide, flooding, volcanics, channel migration zones, tsunami, geologic faults, etc.) and infrastructure inventories (buildings, utilities, lifelines, etc.). The state should continue to invest in lidar acquisition for the purpose of understanding risk to natural hazards at a local scale.	DOGAMI	State IHMT agencies	**ONGOING**
NEW MP-29	Use LiDAR for statewide analysis of all natural hazards		DOGAMI		**ONGOING**
NEW MP-30	Continue to encourage the development of Emergency Action Plans for all remaining high hazard dams in Oregon.	In Oregon, money from FEMA grants is used to help dam owners create Emergency Action Plans (EAP). An EAP helps identify situations where a dam failure might occur, actions to take that could save the dam, if possible, and evacuations in situations that could result in dam failure. There is an Oregon-specific EAP template available, designed for owners of remote dams that have limited personnel. Approximately 75 percent of state-regulated high hazard dams have, or are currently developing EAP's. The State is encouraging the development of emergency action plans (EAP) for all remaining high hazard dams in Oregon.	OWRD		**ONGOING**

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Action Item			Progress				RECOMMENDATION
2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
LEGISLATIVE/ POLICY							
LP-4*	Promote a state disaster and hazard mitigation fund to assist local governments' mitigation and response efforts	The availability of funding to meet immediate emergency needs, including hazard mitigation activities, is a major concern. Federal assistance programs require various matching fund contributions from state and local applicants and are not guaranteed to exist in the future. Legislation has been considered to create such a fund, common to many states, so that financial commitments can be made quickly to support hazard mitigation. The federal Disaster Mitigation Act of 2000 (DMA2K) addresses hazard mitigation planning and projects. This legislation reinforces the importance of mitigation planning, and emphasizes implementing local actions to reduce risk before disasters occur. DMA2K established a federal Pre-Disaster Mitigation (PDM) Program and new requirements for the post-disaster Hazard Mitigation Grant Program (HMGP). Section 322 of DMA2K specifically addresses hazard mitigation planning at the state and local government levels. It identifies new requirements that allow HMGP funds to be used for planning activities, and increases the amount of HMGP funds available to states that have developed a comprehensive, "enhanced" mitigation plan prior to a disaster. States and local governments must have approved hazard mitigation plans in place in order to qualify to receive post-disaster HMGP funds. Mitigation plans must demonstrate that their proposed mitigation measures are based on a sound planning process that accounts for risk and capabilities. Establishing a state fund to assist local governments with hazard mitigation and response efforts would go a long way towards securing and leveraging federal funds.			**X**	ORS 401.536, Oregon Local Disaster Assistance Loan and Grant Account	**X - DONE**
LP-5*	Establish a system of special zones, procedures, restrictions, and conditions to limit development in tsunami inundation zones	capital expenditure for public and private infrastructure, critical lifeline facilities and residential, commercial, industrial and other development do not explicitly factor in potential tsunami-related hazards. Some method for factoring in tsunami hazard information is desirable. One possibility among many is implementation of a system of special zones, etc. that would include the means to determine the appropriate level of allowable activities. A thorough discussion of the policy implications of any proposed land use restrictions would need to precede any decisions. Such discussions would need to factor in the probabilities and areas potentially exposed to distant versus local tsunamis, economic and social coasts of any restrictions, and the potential benefits in terms of life and property saved. Any land use restrictions would need to be based on relatively sophisticated information and mapping that would include a determination of hazardous areas for both distant and local tsunami sources, an evaluation of the hazard, an evaluation of the severity, and the level of allowable risk. Detailed mapping for local Cascadia Subduction Zone tsunamis has been completed for six areas (Warrenton/Astoria, Seaside/Gearhart, Lincoln City, Newport, Coos Bay, and Gold Beach). Mapping for a worst case distant tsunami has been completed for Seaside/Gearhart. The adoption might involve amendment of DLCD's Goal 7.					**X - REPLACED BY: LP-5A, LP-5B, LP-5C, and LP-5D**
NEW LP-5A	Develop land use guidance and best practices for local governments for reducing risk within tsunami inundation zones. This would include model comprehensive plan and code amendments (policies, procedures, incentives, restrictions, conditions, and a tsunami overlay zone).	The risk of tsunami hazard for Oregon's coastal communities is well-documented with the completion of comprehensive tsunami inundation maps developed by DOGAMI. The State of Oregon can assist affected communities by developing land use guidance for tsunami risk reduction, providing it to the communities, then assisting communities with its implementation. Monitoring success of the guidance will allow the State to adjust its approach and update the guidance as necessary.			**X**		**X - DONE. New Tsunami Guidance completed by DLCD in December 2013.**

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Action Item			Progress				RECOMMENDATION
2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
NEW LP-5B	Provide land use guidance and best practices for reducing risk within tsunami inundation zones to local governments.	The risk of tsunami hazard for Oregon's coastal communities is well-documented with the completion of comprehensive tsunami inundation maps developed by DOGAMI. The State of Oregon can assist affected communities by developing land use guidance for tsunami risk reduction, providing it to the communities, then assisting communities with its implementation. Monitoring success of the guidance will allow the State to adjust its approach and update the guidance as necessary.			**X**		**X - DONE. New Tsunami Guidance issued by DLCD in January 2014.**
LP-6*	Integrate hazard data into planning and regulations	Integrate new high-resolution hazard data into local planning and regulations. Special regulations should be established for proposed new critical facilities and/or infrastructure.					**X - Covered by LU-2**
LP-7	Improve ocean shore and related permit process	Enhance where possible the involvement of key state agencies in the ocean shore permit and related permit processes (local government, U.S. Army Corps of Engineers, etc.).					**X - Not a mitigation action**
REVISED LP-8	Develop procedures for escorting vehicular traffic through dust storms	ODOT and OSP both have procedures for escorting traffic under various circumstances. ODOT especially has much experience escorting traffic. It may be possible to develop and implement procedures for escorting traffic through dangerous dust storm conditions.					**X - Duplicative. Part of Traffic Incident Management Plan which is all-hazard based.**
LP-9	Obtain a secure source of funding for wildfire related use of the Emergency Conflagration Act	Currently, when the Conflagration Act is used to respond to wildfire related events, the funds expended by the Office of State Marshal must either be subsequently appropriated by the Oregon Legislature or be taken from an account available to the Office of State Fire Marshal. In the latter case, the result is that monies are used for a purpose for which it was not intended and other valuable programs and projects are negatively impacted. Under this action item, the Office of State Fire Marshal will work with the Oregon Legislature to identify and fund a secure source of funding that will pay the expenses incurred in the use of the Emergency Conflagration Act. Currently, within the budget process, the OSFM has identified the need to have funds held aside for responses.					**X - Not a mitigation action**
LP-11	Work towards the floodplain management goals outlined in the Willamette River Legacy Program	The Governor's office has established a Willamette River initiative that lays out various goals for repairing water quality, restoring habitats, and supporting recreational opportunities. Several proposed actions would support sound floodplain management in the river basin. This includes a proposed action to protect existing functioning floodplains and reconnect historic floodplains, with a target of reconnecting 200 acres per year, 1,000 acres by 2010 focusing on tributary confluence areas between Eugene and Salem. Projected benefits of this action include reduced stream temperature, less severe flooding downstream, improved water quality, improved habitat, and increased natural storage of water. The Governor's office has identified potential funding sources as OWEB grants, CREP enrollments, 319 Grants (watershed restoration), Restoration and Enhancement Grants, Wetlands Reserve Program (WRP) and WREP, TNC utility customer salmon habitat grants, and BPA habitat compensation funds.			**X**		**X - DONE**

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Action Item			Progress				RECOMMENDATION
2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
LP-13	Seek funding for the installation and operation of additional stream gages	The availability of timely and accurate telemetered data from stream gauges is essential for flood forecasting, for prediction of imminent flood hazards, and for response to flood emergencies. Stream gauging data also provide basic hydrologic information for floodplain mapping and watershed management by communities throughout the state. Numerous agencies of the federal government need data from stream gauges for effective management of projects and resources; therefore the installation and maintenance of stream gauges has traditionally been a responsibility of the federal government. State agencies plan to work with their federal counterparts to ensure adequate funding and support for existing gauges and for the installation of new gauging sites where required. It is recommended that state agencies endeavor to leverage federal funding with state resources and local matching commitments to achieve a reliable network of stream gauges around the state.			**X**	2013 Legislature provided funding for 1.75 FTE and 16 additional stream gages.	**X - DONE**
LP-14	Seek funding to enhance capacity of state floodplain management program to better support implementation of the NFIP and higher regulatory standards	DLCD and OEM provide various services to FEMA Region 10, local governments, other governmental agencies, and the general public in support of implementation of the NFIP in Oregon. While coordination and cooperation and pursuit of various federal funding opportunities have allowed the state to temporarily enhance the services provided in some areas, neither DLCD nor OEM have been able to secure funding to permanently enhance the work capacity of the two agencies. FEMA funding is supporting a ~~limited duration~~permanent position focused on RiskMAP. The agencies could more fully serve the needs of local floodplain management programs and the citizens of Oregon if additional resources could be secured.	**X**				**X - Not a mitigation action**
LP-18	Establish a method for verifying the adequacy of geotechnical site reports on an as-needed basis	Independent peer review by qualified and registered geotechnical professionals is one of the best methods of ensuring that site reports done for local governments, property owners, developers, and others are of an acceptable quality and adequately address landslide issues. It is recommended that peer review processes throughout the state be strengthened so landslide hazards are minimized.					**X - Done at the local level**
EDUCATION/ OUTREACH							
EO-2*	Develop a statewide strategy to encourage the purchase of flood insurance	Despite the statewide availability of flood insurance, coverage in place in most communities in Oregon varies from 10% to 20% of the homes and businesses located in the Special Flood Hazard Area (100-year floodplain). Not only does flood insurance reduce the financial vulnerability of individuals, families, businesses, government agencies, other organizations, and the community to the costs posed by flooding, but through the "increased cost of compliance" provision of flood insurance, it also provides funding for the elevation, floodproofing, demolition, or relocation of homes and businesses when required due to "substantial damage" to the structure. State agencies, local governments, and private sector insurance companies need to promote the purchase of flood insurance. Efforts could be linked with NFIP efforts such as the floodsmart.gov website and associated advertising campaigns.			**X**		**X - DONE**
EO-3*	Assist communities to adopt risk reduction techniques and ordinances	Techniques can involve requiring geological or geotechnical studies for new development, storm water control for neighborhoods on hillslopes, strict land use ordinances for active landslides, working with infrastructure operators to increase reliability of services after storms, and more.					**X - Not SMART**

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2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
EO-4*	Encourage Oregon coastal communities to enroll in the NFIP's Community Rating System (CRS) which includes tsunami standards.	The CRS, included in the National Flood Insurance Program, is a FEMA program that provides incentives to communities to mitigate flood disasters. By enrolling in the CRS, communities, through specific actions, receive points that go toward a reduction in insurance rates. Tsunami actions are included in the CRS and have recently been revised by FEMA in conjunction with the Insurance Services Office (ISO). Contact DLCD, OEM, or FEMA for information about the CRS tsunami program.					**X -Covered by EO-1**
EO-5	Improve hazard mitigation technical assistance for local governments and infrastructure operators	A DLCD-led review of the implementation of statewide planning Goal 7 resulted in the identification of several needs to strengthen local hazard mitigation efforts. These included providing current hazard information and technical assistance to local governments, improving communications between local governments and state agencies with respect to natural hazards, and providing hazard mitigation training. An ongoing need to provide technical assistance to local governments exists, and the State IHMT continues to look for ways to bridge the gaps between local planning, building, and emergency management programs, and between the local and state levels. Despite this recognition, implementation of such activities is difficult to fund and institutionalize. Through the Oregon Partnership for Disaster Resilience (OPDR) these issues have been addressed since 1999. OPDR has offered measurable outcomes on how increased communication, coordination, and collaboration between diverse partners (public and private) can assist the state and communities in reducing their risk and exposure to natural hazards. Various State IHMT partners will continue to look for opportunities to provide technical assistance in a manner that encourages coordination among various local programs and informs communities of assistance available. The State IHMT also continues to seek stable non-federal funding for OPDR.. The State IHMT will endeavor to ensure that technical					**X - Not SMART**
EO-6	Develop and distribute local hazard mitigation planning guidance; provide plan development support	The Oregon Partnership for Disaster Resilience (OPDR) assists communities in developing and implementing local risk reduction plans and projects. Funding for planning-related activities comes from the Pre-Disaster Mitigation Grant Program, and 2012 marks the ninth year of regional planning efforts aimed at developing multi-jurisdictional natural hazards mitigation plans. As a direct result of OPDR activities, the majority of Oregon's counties maintain FEMA-approved natural hazard mitigation plans. On October 1, 2012, new FEMA local plan review procedures will be fully phased-in, and this will require outreach and training on a state-wide basis. In conjunction with PDM plan development assistance, OPDR develops and implements training programs that benefit communities, agencies, and partners in natural hazards risk reduction. For communities developing hazard mitigation plans, OPDR develops and facilitates a series of quarterly plan development workshops. The series includes workshops on developing planning processes; involving stakeholders and conducting public outreach; mapping community assets and assessing local risks and vulnerabilities; developing goals and action items; and developing strategies for plan implementation and maintenance. OPDR also hosts a two-part plan update training series and business continuity trainings. In addition to the trainings, OPDR provides communities with support, tools, and resources necessary to develop and/or update their natural hazards mitigation plans. Communities developing natural hazard mitigation plans					**X - REMOVED: Replaced by Revised EO-6A, and new EO-6B, C, D, and E. Parts B, C, D, and E are located in the "Ongoing" spreadsheet.**

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2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
EO-8	Develop tsunami hazard and evacuation maps	Tsunami runup areas and evacuation maps continue to be developed in conjunction with local governments. Tsunamis can dramatically affect coastal erosion and must be taken into account in planning activities.			**X**	**X**	**X - DONE**
REVISED EO-14A	Develop protocols for improving communication of hazardous blowing dust conditions between public safety answering points, ODOT, OSP, and local law enforcement agencies.	Community Solutions Team (CST) meetings in the Mid-Columbia Region of Oregon during the spring of 2000 identified that better communication between public safety answering points (PSAPs) about the existence and likely direction of travel of dust storms might have provided additional warning time for ODOT, OSP, and local law enforcement to stop travel on downwind highways likely to be affected. Protocols should be developed and training provided should be consideredthat would result in PSAPs relaying information, as appropriate, to ODOT, OSP, local law enforcement, and the downwind neighboring PSAP regarding reports of dust storms headed in a particular direction. This may provide additional time for ODOT and law enforcement agencies to briefly close stretches of highways in the path of the storm and/or for reader boards and other advisory systems to be activated with information. There are a number of issues and factors that would need to be addressed in determining the feasibility of developing protocols and training on them: ▪ Staffing/Costs – Some PSAPs do not have more than one or two people per shift on duty; when events such as dust storms happen, personnel sometimes find it difficult to keep-up with existing, ongoing protocols. ▪ Feasibility – If the only information PSAPs have is based on what they are told by callers or mobile police/fire units via radio, will they know enough about the direction of travel of the dust storm to issue reliable information?					**X - Existing protocols for hazardous weather traffic management are sufficient to use for dust conditions.**
NEW EO-14B	Train public safety answering points, ODOT, OSP, and local law enforcement agencies' staff to use protocols for improving communication of hazardous blowing dust conditions.	Protocols should be developed and training providedthat would result in PSAPs relaying information, as appropriate, to ODOT, OSP, local law enforcement, and the downwind neighboring PSAP regarding reports of dust storms headed in a particular direction.					**X - Existing protocols for hazardous weather traffic management are sufficient to use for dust conditions.**
EO-16	Provide additional information to the traveling public about dust storm driving safety	Among the ideas generated by the Community Solutions Team meetings in the spring of 2000 was to provide additional public education outreach in dust storm prone areas of the state, especially Morrow and Umatilla counties. Among the ideas were the following: 1) Provide dust storm driving information in safety rest area kiosks. 2)Develop, print, and distribute "table cards" to area restaurants and truck stops, providing information on driving when visibility is reduced (dust storms, fog, smoke, etc.), perhaps making similar information available at DMV offices. 3)Develop and distribute PSAs on the topic of driving in dust storm conditions to radio stations; stations would be encouraged to run these during peak periods when there is a strong possibility of high winds and blowing dust (Tri-Cities radio stations should be included). Determine the merit of these ideas and implement those that are likely to result in a better-informed traveling public, thereby increasing safety on Oregon's highways.					**X -Replaced by Revised EO-16A, and new EO-16B and C.**
REVISED EO-16A	Provide dust storm driving information in safety rest area kiosks.	Among the ideas generated by the Community Solutions Team meetings in the spring of 2000 was to provide additional public education outreach in dust storm prone areas of the state, especially Morrow and Umatilla counties. This is one action that could save lives and prevent damage in the event of a dust storm.					**X - Safety and weather information is already provided in rest area kioks.**

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2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
NEW EO-16B	Develop, print, and distribute "table cards" to area restaurants and truck stops, providing information on driving when visibility is reduced (dust storms, fog, smoke, etc.), perhaps making similar information available at DMV offices.	Among the ideas generated by the Community Solutions Team meetings in the spring of 2000 was to provide additional public education outreach in dust storm prone areas of the state, especially Morrow and Umatilla counties. This is one action that could save lives and prevent damage in the event of a dust storm.					**X - This is not an effective communication technique and no funding is available.**
NEW EO-16C	Develop and distribute Public Service Announcements on the topic of driving in dust storm conditions to radio stations; stations would be encouraged to run these during peak periods when there is a strong possibility of high winds and blowing dust (Tri-Cities radio stations should be included).	Among the ideas generated by the Community Solutions Team meetings in the spring of 2000 was to provide additional public education outreach in dust storm prone areas of the state, especially Morrow and Umatilla counties. This is one action that could save lives and prevent damage in the event of a dust storm.					**X - Covered by EO-51 (ongoing).**
EO-18	Promote agricultural practices that are known to reduce erosion of soil by wind, thereby reducing the frequency and magnitude of dust storms	It is clear that certain agricultural practices reduce the frequency and amount of blowing dust, as well as reduce wind-caused soil erosion. Oregon Department of Agriculture should continue to work with farmers, agricultural associations, and soil and water conservation districts to further promote and implement: 1)Residue management, including no-till or direct seed farming. 2)Cover crops and other BMPs (see below). 3)Field strip cropping systems. 4)Landscape buffers/windbreaks. The most commonly used practice for both wind and water erosion control is residue management. This involves leaving some or all of the residue from the previous crop on the soil surface to provide cover and surface roughness to provide protection against erosion. Residue management involves tillage practices that do not turn the soil over thus burying the residue. Reduced tillage, minimum tillage, no-till, mulch till, and conservation tillage are all terms used to describe the various methods used to accomplish residue management. Other "best management practices" (BMPs) used in wind erosion prone areas include cover crops, annual or continuous cropping, and crop rotations. On irrigated land, a common practice is to irrigate soon after tillage to form a crust on the soil that reduces the potential for wind erosion. Field strip cropping systems can reduce exposed surface area by up to 50% on each field. Landscape buffers/windbreaks are likely the most expensive alternative because a series of properly spaced tree and shrub windbreaks requires the purchase of trees/shrubs, and since it would likely need irrigation, requires some infrastructure development and maintenance costs. Additionally, to be effective, it needs to be done as a system, involving multiple ownerships. The Coordinated					**X - This is not a stand-alone action, but in practice is done in the course of other Soil & Water Conservation District (SWCD) activities. ODA provides administrative and financial support to the Soil & Water Conservation Commission and the more than 40 SWCD programs; however, ODA has no authority over their activities. Therefore, there is no state agency to champion this action item.**
EO-21	Provide information to local governments regarding adoption of programs and model ordinances for mitigation of existing, hazardous, unsecured buildings elements, such as parapets	Some common building features subject to earthquake damage and corresponding safety hazards include parapets, awnings, signs, decorative features, and masonry moldings. BCD has adopted the International Building Code (IEBC) as an alternate method, which was amended to support Portland's local ordinances on seismic design requirements for existing buildings. Local governments that wish to adopt hazard mitigation standards for existing buildings as permitted by ORS 455.020(4) should follow the City of Portland's local ordinance (Chapter 24.85 Seismic Design Requirements for Existing Buildings).					**X - Not allowed under current law.**
EO-23	Identify an Oregon institution to host the Advanced National Seismic System (ANSS) Interpretive Center in Oregon	The August 2001 implementation plan for the ANSS Pacific Northwest Region identifies a need for an institution in Oregon to interpret ANSS Oregon earthquake data and information products for users ranging from emergency managers and news media to research scientists. This project is, in part, a USGS effort mandated by Congress, which involves the purchase, installation, monitoring, and maintenance of strong motion seismographs					**X - No longer being pursued.**

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2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
EO-24	Continue to improve the communication of historical information on stream flows during past El Niño and La Niña years to water managers throughout Oregon; historical data provides the earliest clue on where flooding may occur or where there could be water shortages.	Stream flow data from past El Niño and La Niña years can provide clues as to where the state is more likely than during an "average" year to experience water shortages or flooding. This information should be better communicated to water managers, floodplain managers, emergency managers, and others with an interest in stream flows. The apparent association of ENSO signals and streamflows shows up only in some basins and some years and thus cannot be relied on with certainty… A forecast based only on ENSO signals may be overly simplified, or in some cases, misleading. (For example) the SOI variable is significant in both the Wilson and Trask rivers but the La Niña variable is not significant in these two basins. Neither variable is significant in the Siletz (which has 60-plus years of record). Although (there is) a potential role for ENSO signals in flood planning, relevance will depend in part on the physical characteristics of individual watersheds and on the particular flow metrics of interest to floodplain managers. An apparently strong ENSO signal in a particular region may be of little use for some individual catchments in the region other factors can play major roles in whether a high flow results in a flood event. Along Oregon's coast, for example, floods in some smaller rivers that empty into bays often are caused by storm surges and high tides in concert with heavy precipitation. These surges and tides pile-up bay water and decrease the rate at which streamflows can be discharged to the open sea.					**X - Not a mitigation action.**
EO-25	Facilitate additional training on seismic design of structures and requirements of the State Building Code relating to hazard mitigation	Facilitate the development of training courses for individuals involved in earthquake hazard mitigation and building design, construction, and inspection. Focus on audiences that include architects, engineers, contractors and code enforcement personnel. The workshops will also provide a forum for instruction on construction and retrofitting techniques to increase the seismic resistance of existing buildings.					**X - Outside BCD authority.**
EO-26	Draft model intergovernmental agreements to establish clear definitions of assistance and authority across jurisdictional lines or when state or federal resources are needed.	Create a model mutual aid agreement to be used by state and local governments when providing assistance across jurisdiction lines. Establish additional clear guidelines when local jurisdictions need additional state, federal, or special resources.					**X - Not a mitigation action.**
EO-30	Expand the Firewise Communities/NFPA program in Oregon	The national Firewise Communities/USA recognition program promotes a self-help approach by which local communities can improve their level of protection from wildfires. Within a community, the program is started when a fire service professional provides information about how the community can successfully coexist with wildfires, explains basic fire mitigation measures, and helps to complete a community assessment of their situation. The community then uses this information to develop and carry out a mitigation plan which is tailored to its unique location and situation. Currently, several of Oregon's communities have participated in the program. More will be encouraged to do so.					**X - Covered by EO-27**
EO-31	Encourage increased commercial utilization of biomass materials from wildland-urban interface areas	For a variety of reasons, vegetative fuels in and adjacent to wildland-urban interface (WUI) areas are accumulating at historically high rates. The ability to properly, cost effectively, or ecologically dispose of such fuels, as a part of a comprehensive mitigation strategy, is often limited and may even be nonexistent in some locales. One way to address this problem is to encourage increased commercial utilization of biomass materials which are created by mitigation activities in WUI areas, such as by burning to create steam and electricity (co-generation). The development of the infrastructure to support such utilization requires significant marketing and investment. Under this action item, the desirability of entering such markets will be promoted to potential developers and investors.					**X - Not a mitigation action.**

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2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
REVISED EO-32	Continue Oregon's annual Wildfire Awareness Week campaign	Creating public awareness of the need to consider and to apply wildfire mitigation actions, such as hazardous fuels removal, on privately owned lands is one of the keys to the successful implementation of a comprehensive wildfire awareness program. In recent years, the states of Oregon and Washington have jointly conducted an annual wildfire awareness campaign, early in the spring. Under this action item, Oregon will devote more time, energy, and money to designing and conducting an annual wildfire awareness week campaign. The goal will be to make residents more aware of the wildfire risks they face and how they can help to reduce that risk.					**X - Covered by EO-27**
EO-35	Floodplain Management Outreach	DLCD has an active floodplain and natural hazards outreach program. The department publishes and distributes newsletters and other outreach information to local governments and other interested parties. DLCD also maintains a website which includes a link to this NHMP. The natural hazards website (http://www.oregon.gov/LCD/HAZ/index.shtml) contains information and links to floodplain management information including many of the documents and booklets prepared by FEMA. DLCD uses an email distribution service for its Natural Hazard Newsletter and other correspondence. The email distribution service affords interested subscribers a greater opportunity to obtain flood management and natural hazards information from DLCD in a timely manner and for DLCD to more readily share information from a variety of sources. DLCD and other State IHMT participants also conduct or sponsor training sessions and meetings throughout the year focused on up-to-date floodplain management practices and projects. DLCD will continue to deliver focused training to surveyors, building officials, real estate agents and planners as well as local floodplain managers. The interdependent relationships among these key players in providing comprehensive floodplain management will also be highlighted during trainings. In addition to the on-going activities mentioned, DLCD will add the following to its outreach program. DLCD will prepare text for local broadcast two Public Service Announcements (PSAs) each year on a seasonal topic					**X - Replaced by E0-35A, B, C, and D**
REVISED EO-35D	DLCD will also disseminate the Floodplain Management Administrative Procedures Guidebook to all 270 OR communities participating in the NFIP.	This guidebook clarifies roles, responsibilities and actions to be taken by local communities. It will also be used during NFIP trainings given to local officials.			**X**		**X - DONE**

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Action Item			Progress				RECOMMENDATION
2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
EO-36	Develop effective means and information to minimize erosion of soils and streambanks during flood events of varying magnitude	Several State IHMT Reports call attention to the need to systematically develop means and information to help minimize the effects of erosion from farmlands, stream embankments, slide areas, farm roads, and other locales. There is a need to promote effective erosion control techniques, including bioengineering of streambanks and planting of riparian vegetation, to help preserve soils, riparian zones, and habitats. Evaluate and use post-disaster funding opportunities (such as the Hazard Mitigation Grant Program) to study the efficacy of natural, bioengineering streambank protection strategies. Potential projects could be the outcome of these studies and proposed treatments that demonstrate cost-effective solutions. DSL is the state agency responsible for issuing the required permits for instream work, and those required to build or repair a levee. DEQ is also involved in the permitting process with help from ODFW, USACE, and the NRCS. DEQ often requires bioengineering in conjunction with the issuance of a permit. DEQ is also responsible for setting water quality standards. ODFW is involved with riparian planting and restoration projects. Various state agencies have opportunities to participate in riparian protection or erosion prevention programs, and those efforts, when taken collectively, should help the state make progress with this action.			**X**		**X - DONE**
NEW EO-37B	Develop maps of rapidly moving landslides						**X - Covered by EO-37**
EO-38	Complete an evacuation mapping GIS database	With funding from the National Tsunami Hazard Mitigation Program all existing evacuation maps are being entered into a GIS database. Data collected for future maps will also be entered into the database. This will provide not only a centralized location for all the evacuation maps but the ability to make maps and permanent signs with a similar format for all coastal areas. The long-term objective is to empower users to make their own evacuation maps through an interactive web site that allows placement of the evacuation zone on a variety of base maps at any scale desired.			**X**		**X - DONE**
EO-40	Public information and education about tsunami preparedness and mitigation	Each year more people visit or move to the coast. There is thus a constant need for public education: what are the tsunami hazards, what to do in the event of a tsunami, and how to mitigate tsunami hazards. This is especially important in light of the problems some coastal counties had during the Nisqually Earthquake in Washington that was felt on the Oregon Coast and the Peru earthquake and tsunami where the Oregon Coast was twice in a tsunami watch. A systematic study of what educational strategies work the best was accomplished in a NTHMP-supported pilot study of Seaside, Oregon (see DOGAMI Open File Report O-05-10). According to polls conducted for this study, door-to-door outreach and evacuation drills were the most effective techniques. As demonstrated in the Seaside study, tsunami evacuation drills help people respond quickly and efficiently to a tsunami warning and generate local media attention to the issue. This is particularly important if a major earthquake is expected to trigger a near-source-generated tsunami. Tsunami surges may arrive within just a few minutes, so it is imperative for people to instinctively know where to evacuate to immediately after the shaking stops. Community Emergency Response Teams (CERT) are an effective means of doing door-to-door outreach and organizing evacuation drills. The long-term objective is to implement CERT in every coastal community. The Seaside format was used in Lincoln City to great success, showing the usefulness of the methods. Leveraging the					**X - Replaced by new EO-40A, B, and C on the "Ongoing" spreadsheet**

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Action Item			Progress				RECOMMENDATION
2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
EO-41	Coordinate an Oregon-specific distant tsunami warning workshop	The Oregon Distant Tsunami Working Group (ODTWG) is a partnership between Federal, State and Local agency representatives; local business partners and community members designed to reduce the impact of distant tsunamis on coastal Oregon communities. Led by Oregon Emergency Management (OEM), the ODTWG is Oregon's community-focused program to improve tsunami mitigation and preparedness of at-risk areas within Oregon. One goal of the Working Group will be to look at how response to a distant tsunami could be applied in the case of a local tsunami. The ODTWG includes Counties, Cities, Oregon Emergency Management, the National Weather Service, the Federal Management Agency, the Oregon Department of Geology and Mineral Industries, Media representatives and community members. This strong and active partnership enables all levels of government to work toward the common goal of saving lives of all people at risk for a tsunami at our state's coastline, and reducing damage to property and the economy.			**X**		**X - DONE**
EO-42	Develop tsunami evacuation maps for all affected communities with established assembly areas	The key to effective tsunami mitigation is to insure that people know what to do and where to go in the event of a tsunami. Evacuation maps that are consistent and easy to read and that identify the safe areas, best evacuation routes and destination sites are critical. With the development of the GIS database the maps can be easily disseminated			**X**		**X - DONE**
REVISED EO-44	Install tsunami signs in all affected coastal communities	Signs reinforce the evacuation maps and tsunami educational materials and are a very visible reminder of the tsunami hazard, where the hazard zone is and where the best evacuation routes are. A few communities have already installed hazard zone and evacuation route signs. Many counties have signs, but are waiting either for the time and/or money or development of evacuation maps before installing them. Robust signage that delineates evacuation routes leading to natural, high ground outside of the tsunami inundation zone is a low-cost, top mitigation priority.					**X - Replaced by E0-62A, B, and C - Ongoing**
EO-45	Encourage local emergency managers with potential volcanic hazards to include volcanoes in their response and natural hazard mitigation plans	State and local emergency managers plan responses for a variety of hazards, including volcanoes. Clackamas County, which includes the southwest portion of Mount Hood, was the first jurisdiction in the nation to complete a FEMA-approved natural hazards mitigation plan, which includes short and long-term proposed actions to mitigate the effects of volcanic eruptions. Local response plan chapters (annexes) developed for volcanic hazards should include pre-eruption through post-eruption sections.					**X - NHMP requirement for affected local governments**

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2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
EO-47	Encourage communities to include volcano hazards, if appropriate, in their multi-hazard mitigation planning process	How a community might respond to volcano hazards depends on a number of things including proximity of the community to the volcano, the nature of the volcano hazards, local volcano history, what is at risk/vulnerable to volcano hazards, and the probability of when or if an event might occur. The difficulty in predicting how catastrophic volcano-associated hazards might be and how often they might occur creates a problem for land use planning solutions. Except for a few Oregon communities on or very near a volcano (e.g., Government Camp on Mount Hood), stringent standards solely based on the prospect of volcanic activity are not realistic. The best approach may be multi-hazards instead of treating volcano-associated hazards separately. A multi-hazard approach would take all natural hazards into consideration during a community's planning process. For example, prohibiting development in the 100-year (1%) floodplain ensures some degree of safety from flood, lahars, earthquake damage (e.g., liquefiable soils), and so on, while preserving the floodplain for natural and beneficial uses. In addition, siting standards for infrastructure and/or critical facilities would include volcano-associated hazards among other hazards to be avoided. DOGAMI published two special papers to help communities look at multi-hazard mitigation: Special Paper 31, Mitigating Geologic Hazards in Oregon: a Technical Reference Manual (Beaulieu and Olmstead, 1999a) and Special Paper 32, Geologic Hazards: Reducing Oregon's Losses (Beaulieu and Olmstead, 1999b). These publications					**X - NHMP requirement for affected local governments**
EO-56	Educate motorists who plan to travel over mountain passes in winter about the need to be prepared	During the December 2003 closure of the Siskiyou Pass on Interstate 5, ODOT and Oregon State Police freed many drivers only to have them spin out and get stuck again. If drivers would have had tire chains, and installed them when conditions warranted, clearing the pass would have been completed hours earlier. Many drivers were not prepared for a long wait in their car. Each year ODOT finds stranded motorists who either do not have or do not know how to install chains.					**X - Covered by EO-49**
REVISED EO-57	Improve geotechnical report standards for the coast.	Numerous local jurisdictions have upgraded the geotechnical report standards for assessing the risk and mitigation measures for development proposed in coastal hazard area.			**X**		**X - DONE**
EO-59	Improve coastal erosion hazard mapping and inventories	Coastal hazard mapping is a long-term program for four reasons. One is budgetary. It is expensive to research and map information for such a dynamic system. Another reason is the dynamic nature of the Oregon coast. Beaches, dunes, and headlands change over relatively short (and longer) time spans. As headlands recede, for example, new maps with new shorelines and erosion rates need to be developed. New technology is the third reason. For example, the tsunami maps issued by DOGAMI are created with the help of sophisticated computer models and high resolution digital elevation models that were not available until a few years			**X**		**X - DONE. Detailed coastal hazard mapping has been done for Tillamook, Lincoln, and Clatsop Counties, and Gold Beach.**

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2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
EO-61	Mandate review for site-specific seismic hazard reports	Independent peer review by qualified and registered geotechnical and engineering geologic professionals is one of the best methods of ensuring that site reports done for local governments, property owners, developers, and others are of an acceptable quality and adequately address site issues associated with earthquake faults and earthquake-caused ground failures. A mandatory review requirement and funding/cost recovery mechanism are needed..					**X - Local action**
EO-62	Install new Entering and Leaving Tsunami Hazard Zone signs in selected areas in the inundation zone along Highway 101.	Existing tsunami hazard zones signs are considered inadequate for placement along stretches of Highway 101, or on any roads, that are within the tsunami hazard zone. A single tsunami hazard zone sign will not indicate the boundaries of the inundation zone. Highway 101 often stays within the inundation zone for miles. Therefore ODOT, in collaboration with OEM, DOGAMI, and the coastal county emergency managers, designed the template for Entering and Leaving Tsunami Hazard Zone signs and placed the signs to identify the hazard zones. Resources for this project were limited, so signs are not present in every hazardous part of the coast highway system. A long-term goal is to complete this project and to reposition signs where new inundation mapping indicates a need. There is need for increased public education program to let the public, including motorists who are not local residents, know what the signs mean and what actions they should take. Additional/ improved signage is proposed to reflect changes in maps by 2015.					**X - Replaced by E0-62A, B, and C - Ongoing**
NEW EO-67	Establish Base Flood Elevation Determination Service	Establish state-approved service to provide Base Flood Elevations to surveyors for the purpose of completing Letters of Map Amendment under the National Flood Insurance Program. Base Flood Elevations are determined by DOGAMI by producing hydraulic models based on lidar topographic data. This is useful in areas where Base Flood Elevations have not been determined by FEMA, though Special Flood Hazard Areas have been mapped.			**X**		**X - DONE**
CI-1*	Complete a statewide evaluation of the condition of levees, dikes, and dams built for flood control purposes	Several reports indicate a broad need to assess the capabilities, conditions, and maintenance of levees statewide to assess performance under flood conditions. As part of the FIRM modernization program, FEMA identified 12 levees in Oregon that are mapped as providing protection against flood waters, but may in fact be deficient. FEMA asked affected communities to complete an accreditation process to prove the levees are capable of controlling the 1% annual flood before they can be shown as providing protection against the 1% annual flood on the FIRM. Five communities managed to complete the accreditation The levees identified by FEMA by no means reflect the full inventory of levees in the state that provide flood protection, but which may be insufficiently or improperly maintained. Many of these levees are privately owned. One of the challenges identified during FEMA accreditation process was confusion over what kind of vegetation is appropriate to allow on levees and how it should be maintained. This is not a new concern. DEQ, ODFW, USACE, and other agencies have been discussing development of a guidance document on preferred levee types and appropriate use of vegetation. At a minimum, the federal agencies NRCS and USACE should be involved with the state agencies noted below in implementing this action item. Dams present another challenge. Regardless of whether a particular dam was designed and built for flood control, the presence of any large dam will serve to reduce the peak flow in the downstream river channel to some degree. Typically, the larger the structure, the greater the corresponding					**X - Combined with CI-16 and covered by REVISED CI-1A-N**
Revised CI-1B	Tsunamis: Complete statewide hazard identification	Identify local and distant tsunami inundation zones			**X**		**X - DONE**
Revised CI-1G	Wildfire: Complete statewide hazard identification	Identify the wildfire hazards including in terms of probabilities			**X**		**X - DONE**

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2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
REVISED CI-10	Promote vulnerability studies of critical infrastructure	Promote vulnerability studies of critical infrastructure (lifelines) to operators. Lifeline services, such as electricity, gas, and telecommunications, can be critical to a community's well being. However, much of Oregon's infrastructure has not been designed to tolerate extreme conditions, such as severe storms, major earthquakes, or large landslides. Certain lifeline services should have reliable performance to ensure that the region can withstand future damage without crippling consequences. Critical infrastructure including energy and telecom utilities infrastructure require vulnerability studies in order to understand potential damages and consequences. Transportation, water, wastewater and other important services are also important.					**X - Covered by CI-7 and CI-8**
CI-11	Determine where additional aquifer studies might lead to greater water supplies and how to fund these studies	There are many areas in the state where the dynamics of the aquifers are not well understood. Studying these aquifers may reveal under-utilized water resources and other information useful to water managers. Determine which aquifers would benefit by detailed studies and how these studies can be funded.					**X - Not a mitigation action. Not SMART. Investigations are an ongoing program under the Integrated Water System Plan.**
REVISED CI-12	Increase storage of water, especially off stream storage	The need to store water is very apparent to irrigators in Eastern Oregon who find creeks going dry during summer and early autumn. One way to avoid that common occurrence is by encouraging storage facilities where they are needed and where they are feasible to construct. In an initial study of potential reservoir locations, storage sites were identified that are very high in drainage basins so that the impact to anadromous fish would be minimal. High elevation, small stream type structures may be considered environmentally acceptable. ODA has also looked at diverting water away from streams through pipelines or canals into off-channel basins. These types of structures are more costly but don't have the impact on fish passage that are oftentimes associated with instream structures. Other ideas include development of aquifer storage and recovery projects. Surface water from streams is diverted during times of abundance and injected into underground aquifers for storage. WRD has developed an inventory of above ground and below ground storage opportunities: http://apps2.wrd.state.or.us/apps/planning/owsci/sw_project_search.aspx http://apps2.wrd.state.or.us/apps/planning/owsci/gw_project_search.aspx. These are also available from the following link, which includes introductory information: http://www.wrd.state.or.us/OWRD/LAW/owsci_info.shtml#Potential_Water_Storage_Sites. Land management practices that slow down or prevent runoff are also being employed by landowners such as creation of wetlands, catchment depressions, diversion dikes, or terraces. The idea is to simply retain water in the					**X - Not a state-level mitigation action. State offers funding and technical assistance to local governments and other entities to build structural water storage facilities.**
CI-15	Require fish passage at all new and replaced structures	ODFW statutes require fish passage at all artificial barriers to fish migration. New structures, such as dams and culverts, are currently required to provide fish passage. Old structures that are replaced need to provide fish passage as well. DLCD, ODFW and OEM will continue to integrate FEMA's 1999 "Policy on Fish Enhancement Structures in the Floodway" policy memorandum into fish passage projects and design guidelines. ODFW will continue to ensure that projects meet fish-passage standards and are also designed with consideration of the need to pass wood and sediment			**X**		**X - DONE**

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2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
CI-16	Evaluate expected earthquake damage and system interruptions to existing lifelines and hydraulic structures, including dams	Lifelines include all essential transportation facilities and the associated bridges, tunnels, locks, and ferries, including airports and railways, petroleum and natural gas pipelines, electric transmission lines, water and sewage systems, "emergency operations and telecommunications infrastructure. The evaluation proposed would study the vulnerability of existing lifeline systems and hydraulic structures to a major seismic event, and estimate the expected damage and losses. Estimating the expected losses will include determining those systems that likely would experience a total loss of operation immediately following a major event, although the actual physical damage to the system may not be total or extensive. In order to implement this action, the State of Oregon will need to work with several federal agencies which are involved in ownership, authority, or responsibility for some of the structures and facilities cited. Detailed benefit-cost analyses (to include hazard damages to facilities, downstream impacts and economic loss of service) can be used to identify and prioritize potential mitigation projects (retrofits, intake relocations, or even new construction).					**X - Combined with CI-1 and coverd by REVISED CI-1A-N**
CI-17	Encourage/require public entities adopt and follow ANSI National Tree Care Standards	This action requires additional scoping to determine how best to encourage and require state and local agencies to adopt and routinely implement ANSI A300, Tree Care Operations Standards. These national standards were developed by a diverse committee of tree care professionals from the private and public sectors and cover proper tree pruning, fertilization, and tree support systems. These standards set forth the requirements and recommendations for satisfactory tree care maintenance. Public entities and tree care companies who perform work according to ANSI A300 standards are following accepted industry practices for proper tree care maintenance operations, resulting in healthier trees with reduced tree hazards. For more information, see: http://www.ansi.org/news_publications/media_tips/tree_care.aspx?menuid=7 This action may result in a legislative concept for a future session of the Oregon Legislature, and may include an incentive such as limited liability when the standards are implemented. Currently, the state has not adopted the ANSI A300 standards, though several state agencies follow them voluntarily. As a first step, the lead and support agencies noted below will better publicize the standards and persuade additional agencies to voluntarily adopt them.			**X**		**X - DONE**

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2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
REVISED CI-18	Introduce legislation in 2015 requiring all overhead facility operators to mitigate service outages due to natural hazards by installing emergency electrical energy generation units; using underground or buried facilities for initial construction in areas where other hazards (e.g., landslide, earthquake, flood) are unlikely cause damage to them; and instituting other mitigation and preparedness measures.	Previous incidents and events demonstrate that overhead facilities are vulnerable to severe storms. The impact of such an event creates safety issues and system outages which, can cause serious concerns to customers, communities, and the public in general as a result of the increasing dependency upon service delivery systems and networks. As such, individuals, local government, communities and commercial enterprises should be encouraged to engage in preparedness efforts in support of service outage mitigation, including the installation of emergency electrical energy generation units. This effort is especially warranted at other critical infrastructure lifeline facilities, where additional health and environmental impacts are witnessed by the loss of commercial power (i.e.:medical facilities and water-waste water treatment facilities). The PUC, in collaboration with industry stakeholders, strives to improve the safety and reliability of overhead lines (ORS:758-010-035) through improved design, construction, maintenance and rights-of-way management. Additional consideration should be given to initial constructs, utilizing underground or buried techniques, as opposed to conversion of overhead lines as a reactionary solution, keeping in mind that underground and buried constructs are vulnerable to geologic and flooding events that may cause the same result, and impact that the conversion of the same facilities was intended to resolve.					**X - The state has no authority to require placement of utilities above or below ground.**
LU-4*	Complete a model "Substantial Improvement/Substantial Damage" program to support local government regulation of floodplain development	DLCD and OEM are in the process of creating a Substantial Improvement/Substantial Damage (SI/SD) manual. The SI/SD Manual will include local ordinance language and companion guidance on administrative processes that can be used by local jurisdictions for cumulative tracking of substantial improvements..It will also address common implementation difficulties encountered at the local level, and suggest approaches that could be used by local governments to overcome those difficulties. The SI/SD Manual will be completed and integrated into Model Code and ongoing NFIP training. (See FL-22 for definitions of substantial improvement and substantial damage.)			**X**		**X - DONE**
REVISED LU-9	Change state land use laws to better connect use of land with water supply	Occasionally land is developed in Oregon utilizing well water without regard to other nearby existing uses. Land developments can reduce recharging of the aquifer that is under them due to sending runoff largely away from the development. Farmers have lost well water or been forced to develop deeper wells due to loss of aquifer water to the newly developed land in the vicinity. Oregon land use law needs to require that new developments not create water hardships on existing land uses and other beneficial uses of water.					**X - Not a mitigation action**

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2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
LU-10	Work with the insurance industry to develop and apply a common standard of interface mitigation measures adjacent to dwellings	The *Oregon Forestland-Urban Interface Fire Protection Act* recognizes that individual property owners are in the best position to take mitigation actions which will have a direct relationship to whether or not their structures survive a wildfire. To that end, the Act required the development of standards that owners are to apply on their property. At the same time, some insurance companies have developed or adopted different standards which their customers must apply on their property in order to obtain or retain insurance coverage. Such a situation of "competing" standards is confusing to property owners and can hamper the application of effective mitigation measures. Under this action item, insurance companies will be encouraged to adopt the Act's standards or, rather than apply a different set of standards, that they will encourage their customers to comply with the Act.					**X - Unnecessary. Insurers generally use NFPA 1144 Standards.**
LU-11	Strongly encourage the adoption of State Building Code standards (or other incentives) for retrofitting, upgrading, protecting, essential facilities, hazardous facilities, and special occupancy structures in coastal communities that are vulnerable to tsun	A large tsunami (and associated earthquake) would likely destroy many buildings in coastal communities that are located in the tsunami inundation zone. The damage would be from the combined effects of the forces from the tsunami surges, currents and debris, as well as the earthquake hazards. The State of Hawaii has adopted construction standards for buildings in tsunami zones. The National Tsunami Hazard Mitigation Program recently completed the document Designing for Tsunamis that outlines some of these issues. These documents could be evaluated and used as a starting point in developing standards. Although not under the jurisdiction of Building Code Standards, port and harbor facilities can benefit from lessons learned from DR-1964 and damages (distant generated tsunami impacts) at facilities in Brookings-Harbor, Depoe Bay and Bandon. Such mitigation measure include strengthen pilings for floating docks, improved dock supports that facilitate unrestricted up down movement during wave surges, and strengthened bulkhead walls that reduce scour from wave surges.					**X - Not allowed under current law.**
LU-14	Develop additional littoral cell plans	The state intends to pursue development of plans for additional sections of coastline, based on need and the level of risk to development.					**X - Will not be done during the life of this Plan**
LU-17	Organize a GIS tsunami database workshop	A GIS database of tsunami safe zones, evacuation routes, and evacuation sites is presently under construction. Once completed, it is important to integrate the data into county databases. The workshop would not only assist counties with how to integrate the data, but also how the data can be used for tsunami evacuation planning.			**X**		**X - Database is done and workshop has been held.**
MP-1*	State IHMT Agency Action Item Progress Reports	Prior to the April State IHMT meetings of each year, State IHMT priority functional category leads will submit progress briefs on all mitigation activities to OEM for review. Briefs will include a progress update on primary action item responsibilities, identification of agency success stories, suggestions for potential new action items and identification of any new or updated information that will be germane to the update of the state NHMP chapters or appendices. Leads will complete success stories for any completed actions at that time. Priority functional categories for the 2012 – 2015 planning period include: • Legislative / Policy • Education / Outreach and • Critical Infrastructure / Essential Public Facilities					**X - Not a mitigation action.**

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2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
MP-2*	Develop post-disaster strategic reconstruction plans based on damage projections from a Cascadia Subduction Zone earthquake and tsunami.	A large Cascadia Subduction Zone earthquake/tsunami may destroy a significant percentage of the buildings in coastal communities, as well as much of the public and private infrastructure that ties them together. Reconstruction of buildings and associated infrastructure will be a massive, long-term undertaking, requiring a great deal of financial aid, planning, technical assistance and cooperation among agencies and the public. Although tragic, such a disaster will also present communities with an opportunity to physically redesign and reshape themselves, creating safer places for people to live and work. A state post disaster planning and recovery task force would be established to plan for reconstruction and to oversee post disaster reconstruction. The Cascadia Region Earthquake Workgroup has recently developed a detailed damage scenario for a CSZ event using HAZUS (Hazards U.S. loss estimation software program) and other information to supplement the HAZUS data. For example, HAZUS does not take into account tsunami damage. This scenario could be used as the basis for developing reconstruction plans.			**X**		**X - DONE**
MP-3*	Monitor hazard mitigation implementation	It is recommended that OEM establish and maintain a formal process to ensure that actions in this plan are being properly implemented. By monitoring implementation of successful mitigation projects, important data can be obtained to support loss avoidance studies that quantify the benefits of mitigation. Monitoring of floodplain and landslide property acquisitions (funded by FEMA mitigation grants) is required and must be reported to FEMA every three years. Although not a federal requirement, monitoring of floodplain property elevations will ensure compliance with meeting NFIP flood insurance requirements. Hazard mitigation implementation may also be reviewed and this plan revised following any Presidential emergency or major disaster declaration. At one time this was a requirement of federal law, but it now is simply a good idea, especially if interest in the event has provided both resources and opportunity for mitigation.					**X - Not a mitigation action.**
MP-4	Maintain a statewide action item database	OPDR hosts a searchable action item database on its website that identifies the actions from existing local natural hazard mitigation plans. During the 2009 Oregon NHMP update, revisions were made to the action item database to allow for local actions to be categorized underneath the state plan goals. This will allow the state or FEMA to quickly sort local actions by the various state plan goals. This function will allow for easier reporting on the State of Oregon's progress towards reducing risk and can be organized under the six Oregon NHMP goals. OPDR is working to add the state plan goal references to actions that are currently listed and is also working to add the actions of new plans as they are developed. Maintaining this database is time and resource intensive; therefore, all local actions may not be categorized during this plan update. This will be an ongoing task for OPDR and OEM staff. Action Item Database: http://csc.uoregon.edu/opdr/actionitems/				Local mitigation actions have been entered into FEMA's database. FEMA's database is not yet accepting state-level mitigation actions.	**X - Not a mitigation action.**

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2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
MP-6	Establish a Silver Jackets Program	The State IHMT should consider establishing a joint state-federal flood mitigation subcommittee, which is tied to a national USACE initiative called "Silver Jackets" (Oregon is not required to adopt this name for the subcommittee). It would provide a forum where DLCD, DOGAMI, OEM, USACE, FEMA, USGS, and additional federal, state and sometimes local and Tribal agencies can come together to collaboratively plan and implement flood mitigation, optimizing multi-agency utilization of federal assistance by leveraging state/local/Tribal resources, including data/information, talent and funding, and preventing duplication among agencies. Objectives of this subcommittee might include: • Facilitate strategic life-cycle flood risk reduction, • Create or supplement a continuous mechanism to collaboratively solve state-prioritized issues and implement or recommend those solutions, • Improve processes, identifying and resolving gaps and counteractive programs, • Leverage and optimize resources, • Improve and increase flood risk communication and present a unified interagency message, and • Establish close relationships to facilitate integrated post-disaster recovery solutions. The State of Oregon will establish a "Silver Jackets", as a subcommittee to the IHMT,with the primary intents of strengthening interagency relationships and cooperation, optimizing resources, and improving risk communication and messaging			**X**		**X - DONE**
MP-7	Revise OEM Hazard Analysis Methodology	Each county in Oregon is required to conduct a hazard analysis within their communities. As part of the hazard analysis, each county develops risk scores for the natural hazards that affect their communities. These scores range from 24 (low) to 240 (high), and reflect the county's perceived risk for each particular hazard. The hazard analysis methodology was first developed by the Federal Emergency Management Agency (FEMA) circa 1983, and gradually refined by Oregon Emergency Management (OEM) over the years. The current methodology could be improved upon to allow for the integration of more detailed risk assessment information. Currently, communities are tasked with determining whether hazards have a 'high,' 'moderate,' or 'low' probability of occurrence; likewise, communities are asked to determine whether their community has a 'high,' 'moderate,' or 'low' vulnerability to each hazard. When better probability or vulnerability data is available, communities should be able to reflect this data in their hazard analyses. Additionally, OEM will work with OPDR to integrate the hazard analysis methodology with the three-phase risk assessment used and taught by OPDR with respect to the development of local natural hazards mitigation plans. In the development of local mitigation plans, the county's hazard analysis scores are typically referenced. If, however, the planning steering committee believes the scores should be different, the scores are simply changed, and the perceived validity of the OEM hazard analysis methodology is weakened. The integration of the analysis with the three-phase risk assessment should therefore be refined.					**X - Not a mitigation action.**

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OREGON NHMP VISION: NATURAL HAZARD EVENTS RESULT IN NO LOSS OFLIFE, MINIMAL PROPERTY DAMGE, AND LIMITED LONG-TERM

Action Item			Progress				RECOMMENDATION
2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
REVISED MP-8	Track key performance measures toward a disaster resistant state.	State "benchmarks" for mitigation have been superseded by Key Performance Measures (KPMs), and are comprised of the following: DLCD KPM #9, "Percent of urban areas that have updated buildable land inventories to account for natural resource and hazard areas"; DOGAMI KPM #1, "Percent of communities and other stakeholders with hazard maps and risk studies for earthquake and landslide hazards"; DOGAMI KPM #2, "Percent target communities with official, reviewed evacuation map brochures"; DOGAMI KPM #3, "Percent target communities with standardized, 4-risk zone erosion hazard maps"; DOGAMI KPM #4, "Public awareness of geologic hazards and mitigation efforts"; DOGAMI KPM #9, "Percent of coastal communities provided with detailed tsunami inundation maps for local emergency planning"; OMD-OEM KPM #10, "Percent of Oregon coastal counties with complete evacuation plans"; and OMD-OEM KPM #12, "Percent of jurisdictions with approved hazard mitigation plans." In combination, these KPMs are moving Oregon toward the goal of developing a disaster resistant state, which institutionalizes hazard mitigation, including: the characterization of natural hazards; the presence of ordinances or standards at the local government level to mitigate natural hazards; and ongoing education on natural hazard mitigation.					**X - Not a mitigation action.**
MP-10	Improve statewide earthquake hazard datasets, develop more accurate and detailed risk datasets, make hazard and risk information widely and easily available	In order to assess the likely impact of future earthquakes, improved shaking models are needed, along with more accurate and detailed mapping of the distribution of soils that might amplify shaking or liquefy, and mapping of areas susceptible to coseismic landslides. This data should be combined with improved asset information to do risk studies using HAZUS and exploring the use of GIS-based exposure analysis. Detailed hazard and risk mapping and modeling provides local and state governments with essential planning tools. Hazard and risk information should be made widely and easily available to planners, decision makers, and most importantly the general public. Easy to use interactive web tools with comprehensive earthquake and multi-hazard information should be deployed statewide .					**X - Covered by new MP10A, (Clearinghouse)**
MP-13	Develop a single, comprehensive statewide method or process to collect and analyze wildfire occurrence data in a timely manner	Currently, data concerning the causes of wildfire incidents is collected and analyzed by at least two state agencies, five federal agencies, and numerous local fire departments. These agencies have no database standardization or common reporting requirements. This results in great difficulty, when attempting to determine the number of wildfires that occur in Oregon, when identifying fire cause trends, and generally in obtaining information concerning wildfire trends in a timely manner. Under this action item, all agencies responsible for suppressing wildfires will be requested to report incident occurrence information to a central data repository, in a standard format, and within prescribed reporting time limits. Such a system would allow for the rapid identification of fire ignition trends and would permit the timely design and delivery of targeted prevention programs and activities. The State Fire Marshal's Oregon All Incident Reporting System (OAIRS) may be a key component in the solution.			**X**		**X - DONE**

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Action Item			Progress				RECOMMENDATION
2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
MP-15	Work to improve forecasting for warning and hazard mitigation	State agencies plan to continue to work with the State Climatologist and the National Weather Service to better understand the nature and frequency of windstorms, and to improve commun-ication of long and short range forecasts in order to allow for improved warnings and lead time for local governments to take effective hazard mitigation actions.					**X - Replaced by New MP-15A and MP-15B**
MP-16	Seek funding for the installation and operation of additional precipitation gauges	The availability of timely and accurate telemetered data from rain (precipitation) gauges is essential for flash flood and debris flow forecasting. State agencies plan to work with their federal counterparts to ensure adequate funding and support for existing gauges and for the installation of new gauging sites where required. It is recommended that state agencies leverage federal funding with state resources and local matching commitments to achieve a reliable network of rain gauges in those areas that are susceptible to flash flooding and rapidly moving landslides (debris flows).					**X - Covered by NEW action following LP-12**
MP-17	Develop statewide resiliency plan consistent with intent of HR3	Set realistic and achievable, graduated resiliency goals. Evaluate existing weaknesses in structures, infrastructure, systems and institutions to identify critical vulnerabilities that will severely hinder response and recovery from a future megathrust earthquake. Develop prioritized and graduated levels of mitigation activity with estimates of costs and benefits. Identify needed mandates, regulations, codes, incentives and educational and cultural changes needed to reach resiliency goals. Prepare written plan and report for 2013-2015 legislature.			**X**		**X - DONE**
MP-18	Support the completion of updated, digital floodplain mapping projects initiated through the FEMA Map Modernization Program (previously short-term action #1) and transition to FEMA's current Risk MAP program.	The state continues to participate in FEMA's national effort to update flood hazard maps, and through the 2004-2009 Map Modernization Program (Map Mod) the majority of flood maps for Oregon have now been issued in a new digital, countywide format. The state will continue to provide support to help manage the Map Mod projects that remain to be completed (Coos, Lane, Tillamook, and Washington Counties), and DLCD will continue to implement the map modernization management support strategy and activities by: 1. Establishing and maintaining a premier data collection and delivery system, 2. Achieving effective long-term management of flood hazard maps, 3. Building and maintaining mutually beneficial partnerships to accomplish mapping work, and 4. Expanding and better informing the flood map user community. Risk MAP (Mapping, Assessment, and Planning) is FEMA's new multi-year mapping program. The program builds on flood hazard data and maps produced through Map Mod while including the vision of building effective community strategies for reducing risk. In partnership with DOGAMI, FEMA contractors, and other state and local agencies, the objectives in Oregon's Risk MAP business plan include: 1. Addressing gaps in flood hazard data, identifying areas of dated and/or inconsistent mapping and updating high-priority areas with new mapping (Coos (remap), Curry, Lincoln, Tillamook, Clatsop, and Klamath Counties, as well as					**X -Covered by MP-5**
MP-19	New maps of precipitation intensity	A basic study of precipitation intensity will be done, including twenty-four hour isopluvials (two, five, ten, fifty, and 100-year maps), as well as development of probable maximum precipitation coverages for Oregon.					**X - Not being done.**

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2012 #	Statement	Description	Not Started	% Complete (1-99)	DONE (100%)	Comments	Remove from 2015 Plan.
MP-21	Develop a post-disaster tsunami scientific data recovery plan	After a damaging tsunami, response and short-term recovery efforts may destroy any scientific evidence of the tsunami, such as surge heights and inundation distances. This data is critical in understanding the tsunami and helping to better prepare for future ones. Once lost it can never be retrieved. Therefore, it is imperative that data gathering be a part of the overall response and recovery plan. This effort should be coordinated with the scientific and technical clearinghouse discussed in the earthquake chapter (short-term #3) and emergency management response and recovery efforts.					**X - Covered by EO-15**
MP-22	Reconvene the committee that oversees the Mount Hood Coordination Plan	The committee including: Oregon Emergency Management, USDA Forest Service, U.S. Geological Survey, Oregon Department of Geology and Mineral Industries, Clackamas County, Multnomah County, Hood River County, Wasco County, the Confederated Tribes of the Warm Springs, Clark County, Skamania County, Washington Emergency Management Division, and the Federal Emergency Management Agency (Region X) should reconvene and incorporate new data from the recent DOGAMI Multi-Hazard and Risk Study for the Mount Hood Region (Burns and others, 2011).			**X**		**X - DONE**
REVISED MP-24	Perform multi-hazard risk analysis at all potentially active volcanoes in Oregon	Multi-hazard and risk analysis should be performed at all potentially active volcanoes in Oregon. For an example see the DOGAMI Multi-Hazard and Risk Study for the Mount Hood Region (Burns et al., 2011).					**X - Covered by new combination of CI-1 and CI-16**
REVISED MP-25	Install a multi-function lahar warning system in areas of high vulnerability	A warning system should be developed for volcano and weather-induced hazards like flood, channel migration, and landslides.					**X - Not being pursued**
MP-26	Develop coordination plans for other volcanoes in Oregon	This action has been completed for Mount Hood. Some similar documents have been completed for other volcanoes in Oregon.					**X - not mitigation**
MP-27	Evaluation of Landslide Risk	DOGAMI will complete this evaluation in cooperation with local municipalities. Specific methods and priority locations are still to be determined.					**X - Covered by new combination of CI-1 and CI-16**